Vandalism
mutilations

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THE CALENDAR

BY THE SAME AUTHOR

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THE CALENDAR:

ITS HISTORY, STRUCTURE AND IMPROVEMENT

BY

ALEXANDER PHILIP, LL.B., F.R.S. Edin.

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PREFACE

THE following essay is intended to serve as a text-book for those interested in current discussion concerning the Calendar.

Its design is to exhibit a concise view of the origin and development of the Calendar now in use in Europe and America, to explain the principles and rules of its construction, to show the human purposes for which it is required and employed and to indicate how far it effectively serves these purposes, where it is deficient and how its deficiencies can be most simply and efficiently amended.

After the reform of the Calendar initiated by Pope Gregory XIII there were published a number of exhaustive treatises on the subject—voluminous tomes characterised by the prolix erudition of the seventeenth century.

The chief authorities are enumerated in the annexed list.

The works of Clavius, Scaliger, Petavius, *L'Art de vérifier les dates*, and Hales are very voluminous—their contents except in the case of Clavius being largely devoted to the elucidation of particular problems in chronology.

The little works of Nicolas and Bond contain many useful and generally accurate calendrial tables and rules, but are both very badly arranged and their explanations often not clearly stated.

The elucidation of chronological problems is one of the main uses of the Calendar and it is the one to which these writers have chiefly attended. This, however, is by no means the only and hardly even the principal purpose for which a Calendar is required. It is also used and required constantly and universally for the fixing of future dates of recurring events and appointments and for measuring intervals of time.

The merits and defects of our Calendar in these respects have recently attracted widespread attention and call for adjustment. To enable this urgent problem to be studied with

intelligence and a due regard to historical, scientific and ecclesiastical requirements on the one hand, and practical uses on the other—such is the principal object of the following essay.

With the exception of the dates of the Nativity and the Crucifixion particular chronological problems are not at all dealt with.

Ancient Calendars, the Indian, Chinese and Mahometan Calendars are only referred to so far as necessary for illustrative purposes, and attention is concentrated on the existing Julian and Gregorian Calendars.

The Calendar is based on certain elementary astronomical facts. The present writer is not an astronomer, but these facts have been derived from the commonly available sources. The intention is to state them with the degree of accuracy requisite for the subject in hand—disregarding qualifying refinements known to modern astronomy but irrelevant to a calendrial purpose.

The most conspicuous, if not the most serious irregularity in our time-scheme is the fluctuation of the date of Easter. It is to be hoped that the courageous action of Lord Desborough in proposing to mitigate this irregularity may lead to the correction of the other defects of the Gregorian Calendar on scientific and conservative lines. Already a Bill to provide a fixed Easter date has been introduced into the House of Lords, and on the initiative of M. Armand Baar of Liège the International Chamber of Commerce has decided to ask the principal Governments to convene a conference on the whole subject.

The writer owes an acknowledgement to his friends James Taggart, Esq., B.Sc., Brechin, and G. E. Allan, Esq., D.Sc. Glasgow, for kindly reading his MS. and making helpful suggestions.

A. P.

Oct. 1921.

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ASTRONOMICAL DATA IN MEAN SOLAR TIME

Length of the tropical year .	365d. 5h. 48m. 46·15s.
Length of the Julian year .	365d. 6h.
19 tropical years . . .	6939d. 14h. 26m. 37s.
19 Julian years . . .	6939d. 18h.
Length of a lunation: 1 . .	29d. 12h. 44m. 2·87s.
12 . .	354d. 8h. 48m. 34·44s.
235 . .	6939d. 16h. 31m. 14s.
Difference between	
a Julian year and . .	365d. 6h.
12 lunations . .	354d. 8h. 48m. 34s.
	10d. 21h. 11m. 26s.
Difference between	
a tropical year and . .	365d. 5h. 48m. 46s.
12 lunations . .	354d. 8h. 48m. 34s.
	10d. 21h. 0m. 12s.
Difference between	
19 Julian years and . .	6939d. 18h.
235 lunations . .	6939d. 16h. 31m. 14s.
	1h. 28m. 46s.
Difference between	
235 lunations and . .	6939d. 16h. 31m. 14s.
19 tropical years . .	6939d. 14h. 26m. 37s.
	2h. 4m. 37s.

A UNIVERSAL CALENDAR FOR THE TWENTIETH CENTURY

Solar Regulars:

Jan. 0	April 6	July 6	Oct. 0
Feb. 3	May 1	Aug. 2	Nov. 3
Mar. 3	June 4	Sept. 5	Dec. 5

Week Day Index:

Sunday 0	Wednesday 3	Friday 5
Monday 1	Thursday 4	Saturday 6
Tuesday 2		

To determine week day add together

(1) Number of year in the XXth Century.
(2) Number of leap years already passed.
(3) Number of the day of the month.
(4) Solar Regular of month.

Then divide by 7, remainder gives day of week as per Week Day Index.

LIST OF AUTHORITIES ON THE GREGORIAN CALENDAR

1. Christopher Clavius. *Kalendarium Gregorianum perpetuum cum privilegio summi Pontificis et aliorum Principum*, Rome, 1582. This essay was annexed to the Papal Bull of 24th February, 1581.

   Romani Calendarii a Gregorio XIII P. M. Restituti Explicatio. Vol. v of Clavius's collected works published in 1612.

2. Hugolini Martelli, Bishop of Glandeves. *La Chiave del Calendaro.* In Lione, 1583. Clear, concise and interesting; one of the best written and least read treatises on the subject.

3. Petavius. *De Doctrina Temporum.* Orig. pub. 1627, and again at Antwerp, 1705. Recognised as the standard treatise on the Calendar—a short abridgement entitled *Rationarium Temporum* deals chiefly with chronology.

4. Joseph Scaliger. *De Emendatione Temporum.* Pub. at Coloniae Allobrogum in 1629. His principal object was to introduce the use of the Julian period—a bitter critic of Clavius.

5. Aegidius Bucherius. *De Doctrina Temporum.* Antwerp, 1634. Contains a detailed account of the various cycles employed for the computation of Easter based upon the cycle designed by Victorius (or Victorinus) of Aquitaine.

6. Sir Isaac Newton. *The Chronology of Ancient Kingdoms amended.* Pub. posthumously in 1728. His chronology is in many cases not accepted, but on matters of calendrial principle the essay is valuable.

7. James Ferguson. *Astronomy.* Pub. 1770, 12th edition in 1809. Deals fully with calendrial problems.

8. *L'Art de vérifier les dates.* 8 vols. Paris, 1783. The stupendous chronological treatise of the Benedictines deals fully with the Calendar.

9. William Hales. *A New Analysis of Chronology*, 1809. A very sound and able treatise.

10. Sir Harris Nicolas. *The Chronology of History*, 1833. Founded on *L'Art de vérifier les dates.*

11. L. B. Francœur. *Théorie du Calendrier*, 1842.

12. A. De Morgan. *The Book of Almanacs.* First edition 1851, third edition 1907.

13. J. J. Bond. *Handy Book of Rules and Tables for verifying dates.* First edition 1869, fourth 1889.

14. *Encyclopaedia Britannica*, 11th Ed. 1910, article "Calendar," by W. S. B. Woolhouse. Excellent—treats calendrial problems algebraically.

PART I

I

THE MEASUREMENT OF TIME

OUR knowledge of time is wholly dependent on measurement. Without the specification of magnitude or quantity the idea of time is meaningless. Now, we can measure time—physically—in one way only—by counting repeated motions. Apart, therefore, from physical pulsations we should have no natural measure of time. In particular the operation of the astronomical Law of Periodicity supplies us with the principal time units.

The primary periodic movements to which we owe our knowledge of time are the two movements of our own earth in which we necessarily participate. These are (1) the rotation of the earth on its axis—which gives us day and night—and (2) the revolution of the earth round the sun—which gives us the year and the seasons. A third uniquely important periodic motion is the revolution of the moon round the earth—which gives us the month.

THE DAY

The earth's rate of rotation on its axis is constant, and a day is the interval between two successive passages of a given celestial object across the meridian. The sidereal day is the interval between two successive passages of a given star. The stars being at an infinite distance, the length of the sidereal day is exactly the same as the time taken by one complete rotation of the earth, and by reference to the record of ancient eclipses it is known that the length of the sidereal day has been invariable for at least two thousand years. The solar day is the interval between two successive passages of the sun across the meridian. As the earth's rate of rotation is constant, it follows that the length of the mean solar day is also a constant quantity. But as the sun

has an apparent motion in opposition to the revolution of the starry sphere amounting to nearly one degree per day, it follows that there is a corresponding difference between the length of the sidereal and the mean solar day.

It follows also that in 365 solar days the earth has really rotated about 366 times. If we go round the earth from east to west we neutralise the effect of the motion above referred to and lose one day. Whereas, if we go from west to east, whilst each day is shorter, we gain a day in the course of the journey.

Again, the sun's apparent eastward motion is not a constant quantity in each successive day. This is owing to the facts, (1) that the rate of the earth's motion in its elliptic orbit is not uniform, and (2) that the ecliptic is inclined at an angle to the equator. There is, therefore, a variation in the actual length of the solar day amounting at its maximum to about 30 seconds. This accumulating from day to day makes a variation in the time of apparent noon amounting to upwards of half an hour—being at a maximum of $16\frac{1}{4}$ minutes before mean noon about 4th November, and of $14\frac{1}{2}$ minutes after mean noon about 12th February. Four times annually, *viz.* on 4th Nov., 12th Feb., 15th May and 29th July, the actual length coincides with the average length of the solar day, which is exactly 24 hours. Four times annually, *viz.* at or about 15th April, 15th June, 1st September and 24th December, the time shown by an accurate clock and a true sundial would coincide. In almanacs the difference between the clock and the sun is usually noted at its maximum point under the entry "clock before" or "clock after" sun.

It is usual to describe the whole period of 24 hours as the civil day—distinguishing it thus from the natural day, which is the interval between sunrise and sunset. The beginning and end of the civil day have been variously computed. In the earliest times it appears to have been usually held to commence with the evening. In the Book of Genesis the account of the creation refers to the evening and the morning as composing the day. This method of computation was also observed by the Greeks, and, according to Caesar[1] and Tacitus[2], the ancient Gauls and Germans computed their times and seasons by the night—a

[1] *De Bell. Gall.* VI, 18. [2] *Germania.*

relic of which is found in our own expression "a fortnight." Amongst the Jews it was also the custom to commence the day with the evening. With the Romans the day began at various hours. According to Macrobius[1] the civil day of the Romans began from the sixth hour of the night, that is midnight. At other times the Romans computed the day from 6 a.m. The hour of Christ's death was said to be the ninth hour, equal to 3 p.m. The night amongst the Jews and other early nations was divided into three watches. The Greeks and the Romans divided it into four watches. In modern times it is usual to compute the day commencing from midnight, but by astronomers the day is held to commence at noon. In 1925 the civil reckoning is to be adopted by them.

The Year

The true length of the year is also susceptible of various interpretations. Astronomers distinguish: (1) The sidereal year or length of the year measured by reference to the fixed stars; (2) the anomalistic year—being the interval between two successive returns of the earth to perihelion; and (3) the tropical year—being the interval between two successive returns of the sun to the equinox. It is on this latter that the seasons depend, and this year is the only one of the three with which we have any concern in the ordering of human affairs, or in the construction of a Calendar.

Arising out of a primitive seasonal or vegetational year the idea of a year astronomically determined was developed amongst the most ancient civilisations of the East at a very early date. At first its length seems to have been taken at 360 days. In the earliest Chinese, Chaldean, Egyptian[2], Greek[2], and, according to Plutarch[3], also in the earliest Latin records, this was the assumed length of the year.

Indeed, all over the Mediterranean area 360 days was the length of the original astronomical year. But long before the Christian era its length was known more accurately. Plutarch tells us that the five odd days were discovered by the second Hermes in Egypt. Herodotus also ascribes the discovery to the

[1] *Saturnalia*, I, 3. [2] Herodotus, I, 32. [3] *Life of Numa*.

Egyptians, and tells us (II, 4) that they added the five days at the end of the twelve months.

According to Sir Isaac Newton *the 360-day year was essentially a lunar twelve-month*, the month being taken to be 30 days in length as the lunation was completed on the 30th day, and the idea of the year being furnished by the seasons and by the succession of the equinoxes and solstices. He suggests that the Egyptians by observing the heliacal risings of prominent stars *first directed attention to the solar year*[1] which they computed to comprise 365 days. Plutarch mentions that the five odd days added at the end of the year were named after five divinities of the Osiris family. This gives a clue to the date when these days were first added to the calendar. The Chinese also, from a very early date, had reached the computation of 365 days. The addition of the odd five days at the end of the year was common to Egyptian, Chaldean[2], Chinese and several other early calendars.

The Egyptians seem to be entitled to the further discovery of the other six hours required to complete the tropical year. Though the odd quarter of a day was not placed in the calendar till the time of Greek influence its recognition is involved in the Sothiacal period[3], and must therefore draw back to a remote antiquity. A still closer approximation to the truth was reached by Hipparchus, the greatest of ancient and perhaps of all astronomers; most famous as the discoverer of the precession of the equinoxes. He detected an excess of at least five minutes in the year length of $365\frac{1}{4}$ days. According to Mommsen[4] the exact length determined by Hipparchus was 365 days, 5 hours, 52 minutes, 12 seconds. Essays by Hipparchus on the length of the year, on the length of the month and on the intercalary or embolismic month are referred to but are now lost. His estimates of the tropical year and of the lunation were adopted by Hillel II when he reorganised the Jewish Calendar in 358 A.D.

The exact length of the tropical year is now known to be 365 days, 5 hours, 48 minutes, 46·15 seconds.

[1] This view is supported by Herodotus II, 4, and Nilsson, *op. cit.* p. 279.

[2] The 365-day year appeared at Babylon from Egypt after the overthrow of the Assyrian empire by Nabonassar; but Chaldea subsequently developed a luni-solar, Egypt a solar calendar.

[3] See p. 41, *postea*.

[4] *Hist. Rome*, vol. IV, p. 586.

The time of reckoning the commencement of the year has also varied frequently. In the earliest times it would seem that the vernal equinox was the most usual date of commencement. With the Egyptians the commencement was made at the autumnal equinox—the reason probably being that that date coincided with the greatest height of the Nile Flood[1]—to them the most outstanding natural event in the year. Very probably from them the Jews derived the custom of dating their year also from the autumnal equinox. To this day the Jewish civil year commences with the month Tisri. But ever since the deliverance from Egypt the ecclesiastical year of the Jews has commenced at the vernal equinox with the month Nisan.

The Month

The time of the moon's sidereal revolution is 27 days, 7 hours, 43 minutes, 11·5 seconds. But here again there is a difference between the sidereal revolution and the apparent interval between two successive full moons. The latter, called by astronomers "the synodical period," is the only period which can be made use of in ordinary human affairs. The actual time of the moon's synodical period is 29 days, 12 hours, 44 minutes, 2·8 seconds.

In the earliest times the length of the lunation was taken at 30 days. This is the length of a month in the biblical account of the Flood, but at a later date all the Mediterranean peoples arrived at the length of $29\frac{1}{2}$ days, and this has been taken as the standard length of a month by Jews, Greeks, and Latins.

The moon's revolution does not affect life so intimately as the motions of our own earth, but still, and perhaps partly as a consequence of its detachment, it has been very much in favour as a measure of time. The moon with its various phases so conspicuous in the heavens serves as a universal natural clock, and the length of the lunation is admirably fitted to supply the practical need for an intermediate unit between the day and the year. The moon's phases are more easily observed by primitive peoples than the positions of the stars or the still more

[1] Herodotus, II, 19.

difficult observation of equinoxes or solstices. According to Mommsen[1] the day and the month being determined by direct observation, not by cyclical calculation, were therefore the earliest time units.

II

THE THREE POSSIBLE FORMS OF CALENDAR

It might be possible to preserve a record of the passage of time by enumerating days in constant succession from some real or imaginary starting point. This, though very inconvenient, might be sufficient for the registration of past events, but it would be useless for what is after all one main object of a calendar, namely, to record beforehand the date of future recurring events.

A calendar is an attempt to establish fixed relations between the day, the month and the year. The variations in the forms which calendars have taken are principally due to the fact that neither the month nor the year is an exact multiple of the day; nor is the year an exact multiple of the month. As a result of this there are three possible forms of a calendar: (1) a solar calendar—that is to say, one which adheres to the true length of the year, but gives an arbitrary length to the month, irrespective of the length of the lunation; (2) a lunar calendar, in which lunar month-lengths are adhered to, but the length of the year is arbitrary; (3) a luni-solar, in which an endeavour is made to observe the true length of both the month and the year, and to adjust their inequalities by means of what are called intercalations.

Notwithstanding its greater complexity, many important calendars of antiquity were of a luni-solar character. In almost every case they took the length of the lunation at $29\frac{1}{2}$ days, and employed months of 29 and 30 days alternately, thus giving a lunar twelve-month of 354 days, which they sought to harmonise with the solar year by the introduction at various intervals of intercalary or additional months. A good example of such a luni-solar calendar is the Jewish. Of a purely lunar calendar the

[1] *Hist. Rome*, vol. 1, ch. xv.

outstanding example is the Mahometan; and of a purely solar calendar the capital instance is the Julian. The observation of the moon's phases being easier than that of the stars, and moonlight being specially serviceable for religious festivals, it is found that luni-solar calendars have a pre-eminently sacral or religious origin[1]. On the other hand, the observation of the stars arose amidst sailors and travellers over plains. Hence a sidereal or solar calendar has a distinctively secular, nautical and commercial reference.

III

THE GREEK CALENDAR

The Greek Calendar was luni-solar from a very early date, and several attempts were made to establish a satisfactory concordance.

According to Macrobius[2] the normal Greek year was a lunar twelve-month of 354 days. Knowing that the solar year comprises $365\frac{1}{4}$ days they added $11\frac{1}{4} \times 8 = 90$ days every eight years. This intercalation was divided into three embolismic months of 30 days. The eight-year cycle was known as the Octaëteris.

There are traces of several variations in this cycle, but the great triumph of Greek chronometry was the discovery by Meton, in or about 432 B.C., that 19 solar years contained 235 lunations. It is understood that Meton took $365\frac{1}{4}$ days as the length of the year. On that assumption, and taking the exact astronomical length of the lunation, the equation is as follows:

19 Julian years of $365\frac{1}{4}$ days	= 6939 days, 18 hours.
235 lunations of 29 days, 12 hours, 44 minutes, 2 seconds	= 6939 days, 16 hours, 31 minutes

As 19 twelve-months amount to 228 months, Meton intercalated seven embolismic months in his cycle. According to Petavius and most authorities, these were introduced in the 3rd, 6th, 8th, 11th, 14th, 17th and 19th years. (Bond gives the seven years which immediately precede these, but no doubt Petavius is correct[3].)

[1] Nilsson, *Primitive Time Reckoning*, pp. 217, 343, 358, etc.

[2] *Saturnalia*, I, 13.

[3] See Table of Perpetual Lunar Almanac, pp. 66, 67; also p. 65 for the natural intervals.

A Metonic cycle, then, is a cycle of 19 solar years, containing in the 1st, 2nd, 4th, 5th, 7th, 9th, 10th, 12th, 13th, 15th, 16th and 18th years, 12 lunar months of 29 and 30 days alternately, and in the other seven years 13 months of similar length, the odd or embolismic month having in the case of six years 30 days and in the case of the last year 29.

Of the 228 normal months one-half or 114 were full months of 30 days, and 114 short or cave months of 29 days. Of the embolismic months six were of 30 days and one of 29. Thus we have:

$$\begin{aligned} 114 + 6 = 120 \times 30 &= 3600 \text{ days.} \\ 114 + 1 = 115 \times 29 &= \underline{3335 \quad ,,} \\ &\ 6935 \quad ,, \end{aligned}$$

showing a deficiency of five days from 6940, which—according to Censorinus—was the length of the cycle. It is probable that these $4\frac{3}{4}$ or 5 deficient days were made up by adding another day to one of the cave months every fourth year—thus anticipating, though for a different reason, the intercalary device of the Julian Calendar. According to Mr Woolhouse, the cycle in practice contained:

$$\begin{aligned} &125 \text{ months of } 30 \text{ days} = 3750 \\ \text{and}\quad &110 \text{ months of } 29 \text{ days} = \underline{3190} \\ &\phantom{110 \text{ months of } 29 \text{ days} = }\ 6940 \end{aligned}$$

High honours were conferred on Meton and Euctemon, the authors of this calendar, and their names are said to have been inscribed in letters of gold on the Temple of Minerva at Athens. At any rate the years of the cycle were numbered successively from 1 to 19, and these numbers as employed to designate in series each particular year were, and have ever since been, called and known as the *Golden Numbers*. In the middle ages the number applicable to any one year was frequently called the Prime. The cycle was then sometimes called the cycle of the Moon[1].

The Metonic cycle is said to have been enacted on 16th July 433 B.C., and the first year of the first cycle ran from that date. It has long been regarded as the masterpiece of Grecian chronology, and has influenced luni-solar adjustments ever since.

[1] *L'Art de vérifier les dates.*

Whether it was independently discovered by Meton, or received by him from the east, cannot now be ascertained, but there is evidence that the value of a cycle of 19 years as a luni-solar adjustment was known to the Chinese. It is stated by Dr Hales[1] that in 2269 B.C. two Chinese astronomers, named Hi and Ho, reformed the calendar, and adjusted the solar year of 365 days to the lunar by intercalating seven months in 19 years.

A disturbing element in the cycle was the fact that the number of leap years which it contained was not a constant quantity. To obviate this inequality Calippus of Cyzicus in the following century proposed a cycle of $19 \times 4 = 76$ years, in which period the number of leap years is always 19, and this improved cycle was substituted in Greece for the Metonic about 330 B.C. But throughout the Christian Era the cycle of 19 years has remained the favourite. There are traces of other cycles in early Greece, notably one of 25 years, but none of these is of sufficient importance to detain us.

It should be noted here that the Greek month was divided into three decades of ten or nine days each.

IV

THE LATIN CALENDAR

The calendars of modern Europe having descended from the Roman, it is necessary to describe its origin and development.

According to Macrobius and Censorinus, the original Roman year contained 10 months, and comprised 304 days. Of these:

6, *viz.* April, June, Sextilis, September, November, December, each 30 days	= 180
4, *viz.* March, May, Quintilis, October, each 31 ,,	= 124
	304

This original year began with 1st March, as is proved (says Macrobius) by the names of the six last months.

These writers say that Numa introduced January and February. Scaliger[2] and Hales[3] dispute the above statement as to a

[1] *A New Analysis of Chronology*, vol. I, p. 37.
[2] *De Emendatione Temporum*, p. 172.
[3] *Op. cit.* p. 43.

10-month year, and hold that the year always contained 12 months[1]. The original ten-month year is repeatedly affirmed by Ovid in his *Fasti*. The poet, with the characteristic obsession of a decimalist, advances various fanciful reasons for its adoption. Plutarch, however, in his *Life of Numa*, states that the Roman year during the reign of Romulus contained 360 days and that the lengths of the months, which he evidently believed to be 12 in number, were very irregular. In his *Roman Questions* he affirms that some were of opinion that the Roman year at first consisted of 10 months, some of which contained more than 30 days. Eutropius, probably with truth, states that prior to Numa the Roman year was confused and without regular division. Even Macrobius refers to two innominate months which, he says, "patiebantur absumi."

According to both Macrobius and Censorinus the two additional months were formally incorporated in the calendar by Numa. They state that he added 50 days to the year, raising its length to 354 days, and that he then deducted one day from each of the six months of 30 days, reducing these to 29-day months. These 56 days thus made available he divided between January and February, but in deference to the superstitious dislike of even numbers which prevailed amongst the Romans, he added a day to January, thus raising the total length of the year to 355 days, and ensuring an odd number to each month except February, which was left with an even number—partly because it was devoted to the Infernal Gods—and partly because, by so doing, Numa ensured that the number of days in the year should be uneven.

To equalise these twelve months with the tropical year, Numa is said to have employed the Greek octennial intercalation, or, according to Plutarch, a dieteris or biennial cycle. A further correction was rendered necessary in consequence of Numa's raising the lunar twelve-month to 355 days. According to Livy (I, 19) a complete correction was provided for in a cycle of 24 years[2].

[1] Mommsen refers to the ten-month year as the earliest, but without adducing proof. He admits that the duo-decimal division was adopted very early.

[2] Or according to some manuscripts 20 years.

Notwithstanding the antiquity and authority of the writers who furnish the foregoing account, it is probably very largely conjectural. According to Ovid, the decemvirs, who were appointed about 452 B.C. (shortly before the time when the Metonic cycle was introduced), made certain corrections in the then existing calendar, and restored the commencement of the year to 1st March, the date in use prior to Numa's reform. It seems not improbable that they also introduced the other adjustments, particularly the adoption of the biennial intercalation or dieteris, consisting of the insertion of an extra month of 22 and 23 days alternately. This intercalary month, which Plutarch attributes to Numa, was well known to the Romans under the name of Mercedonius. At any rate a somewhat irregular scheme of intercalation was still required, and being in the hands of the Pontifices, whose methods and reasons were kept strictly secret, negligence, ignorance, and still more—corruption, led to great irregularities and a resulting dislocation and uncertainty in the Roman Calendar.

It is to be noted, however, that these uncertainties did not extend to the divisions of the months, and the enumeration of the days of each month. A highly practical scheme for the regulation of these details was early established, and survived, without alteration, all subsequent reforms of the Roman Calendar. Its principles will be described after the Julian reform has been explained.

V

THE JULIAN REFORM

Such was the state of matters when Julius Caesar with the help of Sosigenes, an Alexandrian astronomer[1], undertook his immortal reform. We must briefly recount the oft-told tale. His proposals partake in a high degree of the comprehensive simplicity which is a usual feature of works of genius, and which often obscures to the common-place mind the real greatness of the conception. The cardinal feature of the Julian

[1] Pliny, *Nat. Hist.* XIII, 25.

reform was the adoption of the solar year of 365 days, 6 hours as the fundamental unit, and the abandonment of all attempt to adapt either the months or the twelve-month to the length of the lunation. It is now believed that the Julian reform was in principle a reproduction of a reform of the Egyptian Calendar enacted 238 B.C.; possibly designed by the Greek astronomer Eudoxus.

Many of the Roman festivals necessarily bore a relation to the seasons, and Caesar, therefore, deemed it desirable to restore the dates of the dislocated calendar, at least approximately, to their original position with reference to the tropical year. The sins of the intercalators appear to have been principally sins of omission, with the result that calendar dates anticipated the natural events with which they were properly associated; or, *vice versa*, the natural Ephemerides fell on a later calendrial date than that properly appropriated to them. Thus, for example, we find Cicero, four years before Caesar's third consulate, dating the vernal equinox on the ides of May, although that Ephemeris, if the intercalation had been maintained, should have fallen on or about the 23rd of March.

Caesar's first step was to correct this dislocation. He extended the then current year 708 A.U.C., 46 B.C., to an exceptional length. In that year after February he intercalated the usual Mercedonius of 23 days. The length of January being 29 days and February 28, this gave a quarter of 80 days. Then between November and December he intercalated two months of 34 and 33 days. This extraordinary year of 445 days ended just about where the Roman year would have done if the intercalations had been regularly observed. This year was known as the year of confusion, although Macrobius more fittingly called it the last year of confusion. The reformed year which followed was of course 709 A.U.C. or 45 B.C.

The above is the account of the year of confusion given by Censorinus, and confirmed by Macrobius[1]. The account of Suetonius in his life of Julius Caesar, chap. 40, though very brief is quite consonant with these so far as it condescends on detail. Dion Cassius (XLIII) gives the length of this year as 422

[1] *Saturnalia*, I, 13, 14. Macrobius gives its length as 443 days.

days and is followed by Petavius. He makes the intercalation 67 days, thus excluding Mercedonius.

Caesar's second step was to enact that the normal length of the year should be 365 days, with one additional day intercalated after 24th February every fourth year to complete the $365\frac{1}{4}$ days, which was then believed to be the true length of the tropical year. The lengths of the twelve months were fixed so as to exhaust amongst themselves the whole extent of the year thus settled. These lengths, with the probable exception to be immediately mentioned, are the very lengths which have ever since prevailed. Caesar boldly abandoned all attempts to maintain a coincidence between the month and the lunation. The calendars of all or nearly all other nations had hitherto obstinately striven to maintain a luni-solar concordance. Caesar cut the gordian knot, and the Julian Calendar was and is the one great example of a purely solar calendar.

Thus with the single exception of leap day all need for intercalations disappeared, Caesar's experience of the evils of irregular and capricious intercalations having convinced him of the necessity of reducing the intercalations to a minimum.

In 44 B.C., the second year of the Julian Calendar, the name Quintilis was altered to July in honour of its founder, and Augustus subsequently, in the year 8 B.C., persuaded the Senate to alter the name of Sextilis to August. Similar attempts by one or two subsequent emperors to attach their name to one or two of the subsequent months failed to take effect.

Doubts have been suggested as to the exact lengths assigned by Julius Caesar to the several months. Some writers say that under his calendar the month-lengths were 31 and 30 alternately, with the exception of February, which had 29 days in common years and 30 days in leap years. They add that when the name of Sextilis was changed to August, the crafty emperor, desiring that the month named after him should escape the ill-luck which the Romans so constantly associated with even numbers, took a day from February and added it to August, and that then, to avoid an uninterrupted succession of three long months, he reversed the lengths of the four following months, September to December.

This story is inconsistent with the definite statements of Macrobius and Censorinus, but so far at least as regards the transfer of a day from February to August, it is not improbable. It seems quite possible that those two writers, giving only a brief summary of the reform, had not deemed it necessary to refer specially to such a minor subsequent change, or that, writing as they did after the lapse of a considerable time, they had overlooked it. Macrobius indeed hints that some change in the Julian scheme was made by Augustus. The rubric of chapter 14, book I of the *Saturnalia* is as follows: "Quem in modum primum Julius deinde Augustus Caesares annum correxerint." In the text of the said chapter he says:

> Martio Majo Quintili Octobri servavit (Julius) pristinum statum; quod satis pleno erant numero; id est dierum singulorum tricenorumque ideo et septimanas habent nonas sicut Numa constituit quia nihil in his *Julius* mutavit sed Januarius Sextilis December, quibus *Caesar* binos dies addidit licet tricenos singulos habere post Caesarem coeperint.

In *La Chiave del Calendaro*, a rare and learned essay by Hugolini Martelli, Bishop of Glandeves, published in 1583 *con licentia degli superiori*, page 130, a table of the Julian months is given in which February has 29 and Sextilis 30, and on page 148 occurs the following sentence: "Caesar Augustus diem unum detraxit Februario et suo Augusto donavit." Scaliger[1] writes as follows:

> Cum autem Septem fuerint cavi menses in anno Romano Januarius Aprilis Junius Sextilis September November December quorum quinque singuli dies reliquis autem duobus bini additi sunt a Caesare.

The two months to which Caesar added two days each he states to have been January and December. It follows that the other five were raised to 30 days only.

Scaliger also[2] describes and reproduces a calendar "in saxum incisum a Romae repertum." In this calendar August has XXX days, February XXIIX, which apparently meant 28, as to November are given XXXI.

On the whole the probability seems to incline in favour of

[1] *Op. cit.* p. 440. [2] *Op. cit.* p. 232.

the view that Caesar would have been likely to maintain the lengths of the months as near as possible to the average or standard of 30 days, and further would not have favoured a monthly syllabus, which he could not have failed to notice involved a serious and quite avoidable inequality in the length of the two half-years. For these reasons we have little hesitation in accepting the traditional story and in ascribing this obvious blot in the Julian Calendar to the selfish craft of Augustus.

A singular mistake disturbed the first operation of the Julian Calendar. The Pontifices interpreted the instruction to intercalate one day every fourth year in accordance with the usual Roman method of enumeration, by which the number enumerated was inclusive both of the day from and the day to which the computation extended. They, therefore, intercalated a leap day every third year. This continued for 36 years, during which 12 in place of 9 days had been intercalated. This error was corrected by a provision that the 12 years from 9 B.C. to 3 A.D. should be common years[1]. Thus after the expiry of 48 years from the original introduction of the Julian Calendar the normal system was finally brought into operation. It may be noted, however, that chronologers have not recorded this error but have treated the leap years as having succeeded one another regularly from the start.

Julius Caesar prescribed the intercalation of a 366th day to be made after the feast of Terminalia on 23rd February of every fourth year. The 24th February was, by the Roman method, the sixth day before the Kalends of March. This day was to be duplicated. The intercalated day was regarded as a part of the 24th, it was hence that it received the name of bissextus or bissextilis[2]. According to the theory of the Julian Calendar there are only 365 days in a leap year, but one of them, namely the 24th February, comprises two natural days in one civil day. The intercalated day was treated as a mere *punctum temporis*. A person born on that day had his birthday annually on 24th February. Many subtle legal discussions took place under the

[1] Pliny, *Nat. Hist.* XIII, 25.

[2] This term implies a 28-day February, but was not coined before the Augustan correction.

Empire and during the middle ages as to the effect of these provisions. Very curious as are some of the questions raised, it seems unnecessary to refer to them here.

As the week was no part of the Roman Calendar, at least until the reign of Constantine, it seems unlikely that these provisions in any way interrupted the regular succession of week days where these were observed, although this is not quite so certain as some suppose. At any rate such an interruption does not seem to have been the result of the important English statute, *De Anno bissextili*, passed in 21 Henry III, 1236, by which it was provided that "the day of the leap year and the day before should be holden for one day."

VI

MONTH AND DAY IN THE ROMAN CALENDAR

Such, then, was the simple framework of the Julian Calendar. As an instrument of dating it required also the use of some rule for the enumeration of each single day. The method already for a long time in use for this purpose was continued without disturbance.

Three days in each month were taken as fixed points for enumeration—the Kalends, the Nones and the Ides. The Kalends was in every case the first day of the month. In the four months, March, May, July and October, which from the earliest times and throughout the whole length of Roman history had been *pleni*, *i.e.* full length months of 31 days, the Nones were the 7th and the Ides the 15th of the month.

In the case of the other eight months the Nones were the 5th and the Ides the 13th day reckoning from the first day onwards. Dates were determined by enumerating from these days *backwards*. The days of any month subsequent to the Ides were enumerated by computation backwards from the Kalends of the following month. Dates between the Ides and Nones were similarly computed backwards from the Ides, and days between the Nones and Kalends backwards from the Nones. In every case, following the Roman method, both the day *from* and the

The Roman Monthly Calender.

Days of the Month	March, May, July, October. 31 days.	January, August, December. 31 days.	April, June, September, November. 30 days.	February 28-29 days.	
1	Kalendis	Kalendis	Kalendis	Kalendis.	
2	VI.	IV. Ante	IV. Ante	IV. Ante	
3	V. Ante	III. Nonas.	III. Nonas	III. Nonas	
4	IV. Nonas.	Pridie Nonas.	Pridie Nonas.	Pridie Nonas.	
5	III.	Nonis.	Nonis.	Nonis.	
6	Pridie Nonas.	VIII.	VIII.	VIII.	
7	Nonis.	VII.	VII.	VII	
8	VIII.	VI. Ante	VI. Ante	VI. Ante	
9	VII.	V. Idus.	V. Idus.	V. Idus.	
10.	VI. Ante	IV.	IV.	IV.	
11.	V. Idus.	III.	III.	III.	
12	IV.	Pridie Idus.	Pridie Idus.	Pridie Idus.	
13	III.	Idibus.	Idibus.	Idibus.	
14	Pridie Idus.	XIX	XVIII.	XVI	
15	Idibus.	XVIII.	XVII.	XV.	
16	XVII	XVII.	XVI.	XIV.	
17	XVI.	XVI.	XV.	XIII.	
18	XV.	XV.	XIV.	XII.	
19	XIV.	XIV.	XIII.	XI. Ante.	
20	XIII.	XIII.	XII.	X. Kalendas.	
21	XII.	XII. Ante	XI. Ante.	IX.	
22	XI. Ante	XI. Kalendas.	X Kalendas.	VIII.	
23	X. Kalendas.	X.	IX.	VII	Leap Year.
24	IX.	IX.	VIII.	VI.	VI.
25	VIII	VIII.	VII.	V.	VI.
26.	VII.	VII.	VI.	IV.	V.
27	VI	VI.	V.	III.	IV.
28	V.	V.	IV.	Pridie Kalendas	III.
29	IV.	IV.	III.		Pridie Kalendas
30	III.	III.	Pridie Kalendas		
31.	Pridie Kalendas	Pridie Kalendas			

Fig. 1

day *to* which the computation was made were enumerated. The day immediately preceding any of these three fixed points was called *Pridie*, the day before that was the third day from the fixed point and so on.

The days of the month were also distinguished as *fasti* and *nefasti*. *Dies fasti* were days on which the courts were open—business days as we should say. *Dies nefasti* the reverse. Any additional days added to the months by Caesar were declared to be *fasti*. No additional *dies nefasti* nor *dies comitiales* (*i.e.* days when public assemblies might be convened) were instituted by him. These must be distinguished from *feriae* or *dies festi*—religious festivals or holy days.

Where the lengths of the months were altered Caesar provided that the additional days should be held to be added at the end of the month[1], thus securing that no interruption should take place in the dates of religious festivals. Thus if the third day from the Ides of any month was one of the *feriae* or *festi* and if that day was the 16th before the Kalends of the following month, still the religious observance was preserved intact on the third from the Ides, although that day might now become the 17th or 18th before the following Kalends.

The method of backward enumeration seems to us awkward simply because it is unfamiliar, and its use of course required that the exact number of days in each month should be constantly memorised. This obstacle to slovenly thinking (which was always distasteful to the resolute intellect of the Roman) being overcome, the Julian Calendar as an instrument for recording dates both past and future was the most nearly perfect which the world has ever seen—indeed, but for the one fact of its slow secular dislocation with reference to the tropical year, it was practically perfect. It furnished the government and the people of Rome with the immeasurable boon of a perpetual calendar. The programme of future work of each individual, of each city, of each institution, of the army, of the law courts and of the whole State could be definitely fixed and made available; could be at any moment inspected, referred to and understood. These programmes under this calendar were ready for instant

[1] Macrobius, *Saturnalia*, I, 14.

use, remained unchanged until altered, were capable at any moment of being altered to meet altered requirements, or to be more perfectly adapted to the exigencies which experience discovered. Without this simple and perfect instrument it would have been impossible to organise the widespread activities of the Roman empire. The Julian Calendar made that organisation possible, and enabled the rulers of the empire, without steam or electricity, to arrange and administer the orderly government of their many scattered provinces and dominions with a certainty and regularity which have never since been realised.

Very different is the state of matters under the modern European calendar. The observance of week days and the occurrence of Sundays and other movable holidays without any fixed correspondence to the dates of the calendar absolutely prevents the adoption of any fixed working plans. Every year, on 1st January, the whole scheme or system of engagements is overthrown. All gradual, steady improvement of social administration or commercial arrangements is impossible, and the progress so constant and so remarkable in science and the mechanical arts finds no counterpart in the unprogressive confusion which characterises social and administrative arrangements.

The Julian Calendar was not so well suited to serve the other main purpose for which the calendar is required, namely, the measurement of equal intervals of time. The lengths of the months approximated sufficiently to the standard length of 30 days, but the sub-divisions of the months were too unequal for practical use. We are not well acquainted with the methods employed by the Romans for the measurement of intervals. There are frequent references to a period of eight days, known as the *nundinae*, said to have been introduced by Servius Tullius, the eighth day having apparently been a market day without religious significance. Probably, however, the fact that the calendar was perpetual enabled equal intervals to be arranged without serious inconvenience.

VII

THE GREGORIAN CALENDAR

We have seen that the Julian year is 11 minutes, 14 seconds longer than the tropical or natural year—consequently the dates of natural periodic events, and in particular of the equinoxes and solstices, fell annually 11 minutes earlier in the Julian Calendar. This was unsatisfactory. In the course of centuries the seasons would gradually have moved backwards to an earlier calendar date. The difference, however, was so small and the change so very gradual that little practical inconvenience resulted. The discrepancy was chiefly noticed in connection with the observance of Easter. As will be explained later on, the date of Easter, owing to its original derivation from the Passover festival, depended upon the occurrence of the first full moon happening after the vernal equinox.

In 325 A.D. the General Council of Nicea decreed that the celebration of Easter should be uniform throughout the Christian Church. The Decree does not appear to have contained any definite reference to the date of the vernal equinox, but that date was certainly assumed by the framers of the Easter Tables to have been the 21st of March, although in 325 A.D. the equinox actually fell on the evening of the 20th. It may be noted that apart from the excess of 11 minutes in the length of the Julian year there are other causes of variation in the date of the equinox. The fact that the assumed excess of six hours over the even period of 365 days is accumulated and added as one day every fourth year entails an oscillation of the date of the equinox, which might be avoided by an alteration in the years when the intercalary day is introduced.

As time went on, however, the calendar date of the vernal equinox fell constantly earlier. This led to much difficulty and dispute as to the proper date for the observation of the great festival. If the first full moon after 21st March was adhered to it gradually moved further away from the true date of the equinox. In course of ages, as one writer pointed out, the date

of the equinox would coincide with the preceding Christmas; and the 21st March would have moved forward towards the summer solstice.

The matter was brought before General Councils several times. At length the 19th General Council, commonly called The Council of Trent, which assembled in 1545 and continued its sittings for 18 years, authorised the Pope to take the matter in hand. The calendar date of the vernal equinox had by that time receded to the 11th March. Soon after, Giovanni di Novara submitted a proposal to Pope Julius II. After the death of Julius the search for a solution was continued by Leo X, who invited the heads of the Italian Academies, and certain individuals who had studied the subject, to submit proposals. Amongst those submitted was a Treatise by Paul, Bishop of Fossombrone, entitled *De recta paschae celebratione*, another *De Aetatum computatione et dierum anticipatione*, by Basilio Lappi, and one entitled *De kalendarii correctione*, by Antonius Dulciatus. Leo by a letter still extant invited the co-operation of Henry VIII.

When Gregory XIII became Pope in 1572, he found these and other proposals awaiting him. The plan which his advisers favoured most was designed by a Neapolitan physician named Aloysius Lilius. In 1577 the Pope communicated this proposal to the Christian princes and learned academies, and appointed a commission of mathematicians and chronologers to consider it. Finally, on receiving a favourable report, he issued a Bull dated 24th February, 1582, by which the new calendar was promulgated.

That Bull contained two principal provisions:

(1) In order to restore the date of the vernal equinox to the XII Kal. April (21st March) the day which the Nicene Council adopted as the date of its assumed occurrence in 325 A.D. 10 days were to be omitted from the calendar of 1582, the day following the 4th of October being declared to be the 15th. The days from III Nones to Pridie Ides were omitted.

(2) In order to maintain in future a more exact correspondence between the tropical and the calendar year it was provided that three out of every four centurial years should be common

years, instead of leap years as under the Julian Calendar; those centurial years only which were divisible by 400 without remainder being retained as leap years.

Further (3) the use of the Epacts designed by Lilius was also enjoined in place of the Tables of Golden Numbers, and (4) the necessary adjustment of the Dominical Letters was provided for.

The year 1582 was the initial year of the Gregorian Calendar, which was at once adopted by the various countries which recognised the spiritual authority of Rome. France adopted the new style in December, 1582. Switzerland, the Catholic Netherlands and the Catholic States of the Empire in 1583. The Protestant States for a considerable time refused to follow. In 1699, however, chiefly at the instigation of the philosopher Leibniz, the Protestant States of Germany came into line.

In Great Britain the new style was not adopted until the passing of the Calendar New Style Act (1750), under which Act it came into operation in 1752. In consequence of the fact that the year 1700 was a leap year under the Julian Calendar, but not under the Gregorian, the disparity by that time amounted to 11 days, and it was accordingly found necessary to provide that the day following the 2nd of September, 1752, should be called the 14th of that month. Opportunity was taken at the same time to fix the official date of the commencement of the year in England at 1st January, the date which had been taken as the commencement of the year under the Gregorian Calendar, and which had already by a Decree of the Privy Council been adopted in Scotland in 1600. Up till 1752 in England the official date of the new year had continued to be the 25th of March.

These facts must be kept in mind when dealing with English dates prior to 1752—dates between 1st January and 25th March being frequently referred to both of the alternative years—although it should be noted that in intercalating the 366th day in the month of February, England, even before 1752, had treated the year as commencing on 1st January—the February of the intercalation having been the February of the year divisible by 4, on the assumption that the years were reckoned from 1st January.

For some time the change produced considerable discontent in England, and riotous crowds assembled to the cry of "Give us back our eleven days."

The countries which officially profess allegiance to the Greek or Eastern Church have continued to employ the Julian Calendar up to the present day; and have only recently adopted the Gregorian.

However justifiable the correction of the Julian Calendar may have been, there is no doubt that the change was productive of much confusion, which has persisted almost to our day. Customs dependent on the calendar become deeply embedded in the national life, and in Scotland, for example, the adjustment of the half-yearly terms to the new dates was only partially effected. Termly payments of money gave little trouble, but termly engagements of servants, especially in the rural districts, and termly occupations of houses and farms continued to be regulated by the old calendar dates almost up to the present day.

It is important, therefore, to ascertain the cause of this confusion. Had the Gregorian reform been confined to ensuring that for the future the disparity between the tropical and the calendar years should be removed by the omission of leap day from three out of every four centurial years no confusion could have arisen. The trouble was entirely due to the fact that Pope Gregory XIII determined to make the correction draw back to the date of the Nicene Council in 325 A.D. It was for that reason only that the omission of the 10 days in October, 1582, and of the 11 days in September, 1752, was required. Had the consequences been foreseen, there seems little doubt that the reform would have been confined to the future. The inconveniences of a retrospective correction have long been recognised by students of the calendar[1].

The Gregorian adjustment is not absolutely correct. The error of the Gregorian Calendar in 10,000 tropical years is 2 days, 14 hours, 24 minutes. Sir John Herschel[2] suggested a further correction, to be effected by providing that the leap day should be excluded from years divisible by 4000 without remainder.

[1] See Brinkley's *Elements of Astronomy*, p. 262.
[2] *Treatise on Astronomy*, ch. XIII, § 632.

A curious instance of the persistence of the old style is to be found in the date of the financial year of the British Exchequer. Prior to 1752 that year officially commenced on 25th March. In order to ensure that it should always comprise a complete year the commencement of the financial year was altered to the 5th April. In the year 1800, owing to the omission of a leap day observed by the Julian Calendar, the commencement of the financial year was moved forward one day to 6th April, and 5th April became the last day of the preceding year. In 1900, however, this pedantic correction was overlooked, and the financial year is still held to terminate on 5th April, which is about the most inconvenient date imaginable, as it so often happens that the Easter celebration occurs just about that time—indeed one result is that about one-half of the British financial years include two Easters and about one-half contain no Easter date. It would surely be a very simple matter to make the financial year commence with 1st March, in which case the Easter interruption would always occur during the course of the first quarter, causing comparatively little inconvenience, whilst any disturbance due to the incidence of the odd leap day at the end of every fourth February would be entirely relieved.

VIII

OTHER CALENDARS

Many other calendars besides the Julian and the Gregorian have been, and some still are, employed in certain countries. We do not propose to give any account of these except in so far as they may illustrate some relevant calendrial problem.

We therefore pass the Chinese Calendar, interesting though it be, merely remarking that it is luni-solar, containing months of 29 and 30 days alternately, balanced by an intercalation not unlike the Jewish.

We also make no further reference to the Chaldean and Egyptian Calendars, containing features which undoubtedly suggest a common origin and which display a remarkable degree

of accuracy in the knowledge which their framers possessed of the astronomical data on which a calendar is based. Nor is it within the scope of our design to say anything of the early Indian Calendars nor of the interesting Mexican Calendar with its 18 months of 20 days.

The Jewish Calendar

Of calendars still operative the Jewish can claim the most ancient unbroken lineage. It is an excellent example of a luni-solar calendar. The months are of 29 and 30 days alternately. The equalising intercalary month is introduced usually every third year. Now and ever since the adjustments made by Rabbi Hillel II in 358 A.D. the intercalations are made in the 3rd, 6th, 8th, 11th, 14th, 17th and 19th years. The intercalary month is introduced after the month Adar at the end of the ecclesiastical year and is called Veadar.

The original Jewish year commenced with the month Tisri, at the autumnal equinox—a fact which suggests an Egyptian origin. This is still the commencement of the civil year; the ecclesiastical year begins with the month Nisan six months earlier at the vernal equinox. Veader is intercalated immediately before Nisan. Further, to enable the luni-solar adjustment to be maintained as nearly accurate as possible the Jewish Calendar recognises three different lengths for the year whether normal or embolismic. There are common years of 354 or 384 days, perfect years of 355 or 385 days and imperfect years of 353 or 383 days as the case may be.

It has been alleged that the use of the intercalary month cannot be traced earlier than the date of the establishment of the Metonic cycle by the Greeks. This, however, is uncertain. The use of the 19-year cycle can be traced in various countries at a very early date, and it is impossible to say where it first originated, or whether, as seems likely, it may have been independently discovered in more places than one.

At any rate it is certain that the Jewish months always commenced with or very nearly with the new moon and the effect of the intercalations is to ensure that the lunation corresponding

to the month Nisan is always that during which the vernal equinox occurs, although of course as the intercalation is not made annually it inevitably happens that the commencement of Nisan does not coincide with the date of the vernal equinox, only that the vernal equinox always falls sometime whilst that lunation is in progress.

The Mahometan Calendar

A luni-solar calendar with lunar months and an intercalation somewhat similar to the Jewish was familiar to the Arabs in the time of Mahomet. That remarkable man was not a philosopher and certainly not what we should call a man of science, but he seems to have been possessed by a singular intuition of reality which is reflected in many of his civil and ecclesiastical institutions. Like so many other men of keen perceptions Mahomet recognised the immense importance of the calendar in the working of the social machine, and the Mahometan Calendar which he introduced bears the impress of his extraordinary character. It seems probable that he found the established system of intercalations disturbed by abuse and corruption, just as was the case in Rome before the Julian reform. He therefore absolutely suppressed the use of the intercalary month, alleging that twelve was the number of months according to the ordinance of God, and that a thirteen-month year was contrary to the divine appointment[1]. Ever since its institution the Mahometan Calendar has been purely lunar—the one outstanding example of such a calendar in actual use. Under it the day and the moon's period are the only natural units. The extreme simplicity of such a rule may largely compensate for its entire failure to maintain a fixed relation with the seasons of the year. Such a calendar is probably only possible in lands where the difference of the seasons is not so marked as it is in more temperate regions. The call it imposed on his followers to ignore the law of Nature in their regulation of their time-scheme may be regarded as an item in the ascetic appeal which Islam makes to its devotees.

[1] Koran, chap. 9. Sale's transl. p. 153. See also Nilsson, *op. cit.* p. 252.

The French Republican Calendar

The short-lived Revolutionary Calendar of the French Convention was instituted on 24th November, 1793, and only survived until 31st December, 1805. This calendar has little historical or scientific importance, but the attempt is not without instruction.

The Convention commenced their new era with the autumnal equinox of the year in which the republic was founded, *viz.* 22nd September, 1792. It was decided that the autumnal equinox should thereafter be the commencement of the civil year which was divided into 12 months of 30 days each, with five supernumerary days at the end of each year. The week was abolished and the month divided into three decades of 10 days each.

This calendar claimed to be founded on a purely scientific basis, but like most scientific reforms introduced by politicians unacquainted with science and impatient of practical tests, it bears marks of haste and superficiality, and also of a total disregard of the advantages of continuity. Its chief features were strangely archaic. The adoption of the autumnal equinox as the commencing date of the year, though made for a different reason, was a reversion to the rule of the ancient Egyptians who were influenced by the fact that the Nile flood was then at its height. The addition of five intercalary days at the end of the year was a reproduction of the ancient Chaldean plan and was detrimental to the value of the calendar, both as an instrument of dating and as a means of measuring out equal intervals of time. The division of the month into three decades was also a revival of a feature of the old Greek Calendar. No consideration seems to have been given to the question of suitability for practical use, and even if the enemies of the Revolution had not been in any haste to abolish it we may doubt whether its use would have been permanently established after the revolutionary fever had abated. At any rate, for the purposes of historical study it would have been necessary to maintain the concurrent use of a dating system which maintained continuity with the past—to break with which was probably one of the main objects of the promoters of the Revolutionary Calendar.

IX

THE WEEK

The legalisation of the weekly Sunday within the Roman empire effected a very serious dislocation of the Julian Calendar. It deprived that calendar of the advantages of perpetuity. The week now occupies a position so important in the calendars of the modern world that we must devote some space to its history.

In the widespread Mongolian or Turanian race described by Isaac Taylor as "the ethnological substratum of the whole world[1]," and with which we should probably associate the megalithic remains so extensively distributed throughout the world, there are evident traces of the early observance of a five-day week. Such a week, for example, has long been known in China.

A week of five days was also observed amongst what ethnologists now describe as the Nordic Race—the race which inhabited the lands surrounding the Baltic, and by whom rather than by Teutonic inhabitants of central Europe it is now well established that the British Isles were largely colonised. It seems probable that the blood of these Nordic races contained a Turanian admixture. That, however interesting, does not directly concern us now, but their calendar does.

Our knowledge of the Northmen's Calendar is imperfect, but there is ample evidence that it contained 12 months of 30 days, each containing six weeks of five days each. M. Paul du Chaillu[2] gives us the names and etymology of the twelve months taken from Skalds Kaparmal, c. 63. Du Chaillu adds:

> The month was divided into six weeks, each week contained five days. The days were called:
>
> Tysdag ... Tuesday
> Odinsdag ... Wednesday
> Thorsdag ... Thursday
> Frjadag ... Friday
>
> Laugardag (bath-day) or Thvattdag (washing-day) = Saturday[3].

The etymology of the first four is obvious, they being named after the four principal deities of Northern Paganism. Whether

[1] *Etruscan Researches*, p. 34. [2] *The Viking Age*, ch. IV, pp. 37–8.
[3] See Lord Dufferin's *Letters from High Latitudes*, p. 64.

the etymology of Saturday is really to be explained as Du Chaillu suggests, or is to be traced to the name of a Norse divinity, Saeter, may be questioned. It had evidently no direct derivation from the classical Saturn as is often alleged, having been used at a time when the name of Saturn was unknown in Scandinavia. Several passages in the Sagas confirm the use of the five-day week[1].

The names of our week days make it clear that this five-day week at one time prevailed in Britain. No doubt the missionaries of Christianity were responsible for the introduction of the seven-day week, and by a compromise with paganism, not unusual, they accepted the established names of the five days and contented themselves with giving to the two additional days the names they had already received in other parts of the Roman empire. The different principle of nomenclature is obvious even before one has learned the true explanation. At any rate the elucidation of the origin of our week-day names points us to an altogether lost but doubtless interesting chapter in early British history.

The seven-day week is of Semitic origin. Traces of it are to be found among Chaldean, Egyptian and even Greek records. Indeed amongst many peoples the number seven seems to have been endowed with peculiar significance. But it was among the Jews that the seven-day week was fully developed, and it is from them that its observance has spread over, and now so largely dominates, the civilised world.

Whether it represents the special value and veneration attached to the number seven or has reference to the number of the planets or of notes in the musical scale, or whether it is a rude attempt at a quarterly division of the lunar month cannot now be ascertained, although the idea that it had any reference to lunar phases is negatived by the fact that the number seven and periods of seven are so frequently used in Jewish law in cases where there was no connection with the lunar month[2].

[1] For other traces of the five-day week see Nilsson, *Primitive Time Reckoning*, p. 328.

[2] Nilsson, *op. cit.* p. 330, holds it to be clear that the seven-day week has not arisen from the phases of the moon, but that those phases have been arranged in accordance with the septenary scheme.

According to Jewish tradition it was instituted at the creation, the successive stages of which it was believed to symbolise. Its observance, having been neglected, was revived whilst the children of Israel were journeying through the wilderness. The daily supply of heavenly manna which was vouchsafed to them was omitted on the seventh day, to compensate which a double portion descended on the sixth[1]. Embodied in the Fourth Commandment the observance of the week has ever since been regarded as of divine obligation upon Jew and Christian. It is to be noted, however, that its observance was enjoined upon the Jews as a mark to distinguish them from the Gentile nations. In Ezekiel xx, 12–20, we are told that God gave the Israelites the Sabbath to be a sign between him and them. The usual gloss on this passage is that the observance of Sabbath was to serve as a distinction between them and other nations.

Among the Jews the seventh day was named and observed as the Sabbath, the other six were merely identified by their number as First, Second, etc., unless that latterly the sixth day was frequently called the preparation.

The term Sabbath[2] was not confined by the Jews to the seventh day of the week. Various other holy days were called Sabbaths. On the weekly Sabbath all work was forbidden, on the other Sabbaths the prohibition generally was limited to "all servile work," but the full prohibition applied to one of these special Sabbaths, *viz.* the Great Day of Atonement.

Besides the weekly Sabbath there were seven of these holy days annually. These were:

1 and 2. The first and seventh days of the Feast of Unleavened Bread.

3. The day of Pentecost or First Fruits.

4. The Feast of Trumpets, 1st of Tisri.

5 and 6. The first and eighth days of the Feast of Tabernacles.

7. The Great Day of Atonement.

It is generally understood that these special Sabbaths did not interfere in any way with the weekly succession, although

[1] Exod. xvi. 23–30.

[2] In Babylonia *shabbattu* meant originally the day of full moon.

the practice in early times must be uncertain, especially in view of the fact that in several cases these days were ordered to be duplicated and observed during two natural days, in order to ensure an observance at least partially simultaneous throughout the Jewish world. The Jewish month being lunar and the first day of each month being ascertained by the actual visibility of the new crescent, uncertainty might and sometimes did exist as to the true day on which the month began. Hence the duplication above referred to which applied and still applies, at least to Pentecost and the 1st of Tisri.

It is thus evident that there is most ample ancient sanction for the observance of two Sundays in immediate succession, and also that the ancient Jews either intercalated an additional Sabbath between two seven-day weeks or else that the injunction of the Fourth Commandment, "six days shalt thou labour," was not interpreted so literally as to exclude the occasional prohibition of work on one of the six working days of certain seven-day weeks.

In commemoration of the fact that the Resurrection of our Lord took place on the first day of the week, and also that the foundation of the Christian Church at Pentecost took place on the same day, the early Christians commemorated the first day of the week as the weekly day of rest and worship. For some time, indeed, they continued, in certain places at any rate, to observe the seventh day also. Ultimately, however, this double observance was abolished by the Council of Laodicea in 364 A.D., the reason for their decision being that the practice savoured of judaising, not at all that a departure from six continuous days of labour in each week was a contravention of the Fourth Commandment—a view which, if sound, would prohibit all holidays or weekly half-holidays, whether devoted to religion or to recreation. To some extent the double observance continued to a later date in outlying regions. For example, St Columba held Saturday as the day of rest from work, whilst on Sunday he commemorated the Resurrection by a religious service[1].

There are, therefore, plenty of ancient precedents for a *five-day working week*.

[1] Adamnan's *Life of St Columba*, ed. 1874, p. 96.

The true view of the Christian duty in regard to the observance of Sunday is well stated by Dr Thomas Arnold in a letter dated 22nd February, 1840[1], as follows:

An ordinance of Constantine prohibits other work but leaves agricultural labour free. An ordinance of Leo I (Emperor of Constantinople) forbids agricultural labour also. On the other hand our own reformers[2] required the Clergy to teach the people that they would grievously offend God if they abstained from working on Sundays in harvest time; and the Statute of Edward VI, 5th and 6th, chap. III, expressly allows all persons to work, ride or follow their calling whatever it may be in case of need. And the preamble of this Statute, which was undoubtedly drawn up with the full concurrence of the principal reformers if not actually written by them, declares in the most express terms that the observance of all religious festivals is left in the discretion of the Church, and therefore it proceeds to order that all Sundays with many other days named shall be kept holy. And the clear language of the Statute, together with the total omission of the duty of keeping the Sabbath in the Catechism, although it professes to collect our duty towards God from the four first Commandments, proves to my mind that in using the fourth Commandment in the Church Services the reformers meant it to be understood as enforcing to us simply the duty of worshipping God, and devoting some portion of time to His honour, the particular portion so devoted and the manner of observing it being points to be fixed by the Church.

After the legal establishment of Christianity in the Empire during the fourth century various enactments were passed for the observance of Sunday, the indirect effect of which was to put the seven-day week into an intimate relation with the other elements of the calendar. Most of these are collected in the Code (Justinian), Lib. III, Title XII, *De Feriis*. They include: Cap. 3. A constitution by which Constantine in 321 A.D. enjoined the solemn observance of Sunday but permitted agricultural work. His rescript makes use of the term *dies solis*. In later legislation, as Gibbon (ch. XX, note *g*) points out, the term usually employed is *dies dominicus*—the Lord's Day. Cap 2. An enactment of Theodosius fixing various *feriae* and making the *dies dominicus* a legal blank day. Cap. 7. A constitution ascribed to Valentinian, Theodosius and Arcadius, dated 389 A.D.,

[1] *Life*, vol. II, p. 176.
[2] See Cranmer's Visitation Articles.

by which various *dies feriae* were provided, including the birthdays of Rome and Constantinople, the fifteen days of Easter, Christmas Day and Epiphany. With regard to Sunday it was decreed that:

> In eadem observatione numeramus et dies Solis (quos Dominicos rite dixere majores) qui repetito in sese calculo revolvuntur: in quibus parem necesse est habere reverentiam: ut nec apud ipsos arbitros vel a judicibus flagitatos vel sponte electos ulla sit cognitio jurgiorum. Nostris etiam diebus qui vel lucis auspicia vel ortus inperii protulerunt.

By constitutions of Leo in 469 A.D. further provision was made for the observance of Easter and of Sunday. In particular by Constitution LIV, under the rubric *Ut dominicis diebus omnes ab operibus vacent*, provision is made for a suspension of all work on Sunday inclusive of agricultural work.

X

THE DOMINICAL OR SUNDAY LETTER

In consequence of these various enactments and of the general practice of the Church, the seven-day week, or more correctly the various week days, acquired a definite relation to the other elements of the calendar, which became more stringent through the need which arose for a calendrial rule to determine the Easter date. It therefore became necessary to devise a method for ascertaining for any given year the constantly fluctuating relation between the week and the month, and in particular for readily ascertaining the calendrial dates of the Sundays in any particular year.

This device known as the Dominical or Sunday Letter must now be described.

The table of the Week Day Letters in no way depends upon or refers to the lunar calendar, but is employed solely for the purpose of indicating the relations between the day of the month and year in the civil calendar on the one hand, and the day of the week on the other. To every day of the year there is attached

one or other of the first seven letters of the alphabet, thus: January 1*A*, 2*B*, 3*C*, 4*D*, 5*E*, 6*F*, 7*G*, 8*A*, and so on.

In leap years the 29th February has *no* letter.

It is obvious that under this arrangement the same day of the week will always have the same letter of the alphabet throughout any given year except where the introduction of leap day occurs. Whatever letter coincides with the first Sunday of the year will, therefore, necessarily be the letter attached to every subsequent Sunday. This letter is called the Dominical or Sunday Letter of that year. It follows that if we know the Dominical Letter of any given year we can tell the whole order of the days of the week within that year.

To ascertain the order of week days in each year we require:

(1) A table showing the Dominical Letter for each year, and

(2) A table of the seven different almanacs varying in accordance with the different week days with which the year may begin.

We append:

(1) A table of the Dominical Letter of every year of the Christian Era from 1700 to 4000 A.D. (Fig. 2).

(2) A table showing the almanac for every year after the Dominical Letter is known (Fig. 3).

It will be seen that the possible almanacs of monthly and weekly correspondence, leaving out the Easter adjustments, are only seven in number for common years, and seven for leap years.

Accordingly, if from Table Fig. 2 or otherwise the Dominical Letter of any given year is known, the almanac for that year can be found immediately in Table Fig. 3. It is also obviously possible, without any second table, on being told the Dominical Letter to ascertain what day of the week falls on 1st January of the year in question.

In order to become thoroughly familiar with the use of the Dominical Letter it is important constantly to keep in mind the distinction between:

(1) A table of Week Day Letters, *i.e.* the first seven days of the year, and every succeeding seven days—indicated by the first seven letters of the alphabet, thus:

January 1st	*A*	8th	*A*
2nd	*B*	9th	*B*
3rd	*C*	10th	*C*
4th	*D*	11th	*D*
5th	*E*	12th	*E*
6th	*F*	13th	*F*
7th	*G*	14th	*G*

and so on to 31st December.

(2) And a table which, from the day of week on which 1st January falls, indicates the Sunday Letter for the year, thus:

If 1st January is Sunday, Sunday Letter is *A*.
" " Monday, " " *G*.
" " Tuesday, " " *F*.
" " Wednesday, " " *E*.
" " Thursday, " " *D*.
" " Friday, " " *C*.
" " Saturday, " " *B*.

These tables are the counterparts of each other, but at the same time one is very apt to confuse them unless care is taken to distinguish them.

If these distinctions are kept in view they enable us to understand the use of the solar cycle.

In consequence of the unfortunate fact that leap day intervenes in the course of every fourth year, two Dominical Letters are required to indicate correctly the calendar for any leap year, and as leap year occurs once in four years, it follows that in place of seven almanacs being sufficient and repeating themselves in a constant succession, a cycle of 28 years is required to reproduce the various possible almanacs in the same order.

The operation of this cycle is well seen from the table (p. 91) giving the years with identical calendars during the first half of the twentieth century.

The cycle is somewhat inaptly called "The Solar Cycle," simply because it deals with the succession of the week days within the solar or tropical year, and without any reference to the phases of the moon. In this respect it is distinguishable

from the other cycles employed in the determination of Easter, and this is the only reason for its name.

The solar cycles are held by convention to have commenced with the year 9 B.C. and the year 1 A.D. was No. 10 of a cycle. To find the number of this cycle applicable to any given year the rule is therefore simple—add 9 to the date and divide by 28. The remainder is the number required; if no remainder the number is 28.

According to the foregoing rule the year 1896 was the first year of a new cycle. A continuous sequence of these cycles from 9 B.C. is assumed in most almanacs. But such a sequence is only valid for the Julian Calendar. The change over to Gregorian broke the then current cycle. Moreover the intervention of a centurial common year dislocates the cycle in which it occurs, although the 28-year period applies whenever it is not thus interrupted. In the annexed Tables, Figs. 2 and 4, this dislocation is provided for, the Dominical Letters for centurial years being first placed by themselves. The Tables in Bond's *Handy Book*, pp. 38–52, may be usefully consulted; also an interesting essay on the Irregularities of the Calendar by Mr F. A. Black, F.R.S.E.[1]

If 1–7 January are represented by *A–G*, it follows that 1–7 March are represented by *D*, *F*, *G*, *A*, *B*, *C*. It is therefore quite easy to construct a table of the Dominical Letters and a table of the almanacs for a year commencing 1st March. Such tables are annexed hereto[2]. They have this great advantage that they serve without alteration either for common or leap years, and are simpler and equally serviceable[3].

[1] *Problems in Time and Space*, p. 34, etc.

[2] Figs. 4 and 5.

[3] Fig. 4 would serve without alteration if the half years were balanced by transferring a day from August to the following February.

Years by which the given year exceeds the hundreds of years.				Hundreds of years after Christ.			
				1700 2100 2500 2900 3300 3700	1800 2200 2600 3000 3400 3800	1900 2300 2700 3100 3500 3900	2000 2400 2800 3200 3600 4000
				C	E	G	B A
1	29	57	85	B	D	F	G
2	30	58	86	A	C	E	F
3	31	59	87	G	B	D	E
4	32	60	88	F E	A G	C B	D C
5	33	61	89	D	F	A	B
6	34	62	90	C	E	G	A
7	35	63	91	B	D	F	G
8	36	64	92	A G	C B	E D	F E
9	37	65	93	F	A	C	D
10	38	66	94	E	G	B	C
11	39	67	95	D	F	A	B
12	40	68	96	C B	E D	G F	A G
13	41	69	97	A	C	E	F
14	42	70	98	G	B	D	E
15	43	71	99	F	A	C	D
16	44	72		E D	G F	B A	C B
17	45	73		C	E	G	A
18	46	74		B	D	F	G
19	47	75		A	C	E	F
20	48	76		G F	B A	D C	E D
21	49	77		E	G	B	C
22	50	78		D	F	A	B
23	51	79		C	E	G	A
24	52	80		B A	D C	F E	G F
25	53	81		G	B	D	E
26	54	82		F	A	C	D
27	55	83		E	G	B	C
28	56	84		D C	F E	A G	B A

Fig. 2. The DOMINICAL LETTERS for years from 1700 to 4000 A.D. New Style. Year from 1st January to 31st December.

A Calendar for any Julian or Gregorian Year.

Common Years.

Dominical Letters and Initial Days (Common Years)							Jan 31 days, Oct. 31	Feb 28 days, Mar 31, Nov 30	April 30 days, July 31	May 31 days	June 30 days	Aug. 31 days	Sept. 30 days, Dec. 31 days
A.	G.	F.	E.	D.	C.	B.							
Sun.	Mon.	Tu.	W.	Th.	F.	Sat.	1 8 15 22 29	5 12 19 26	2 9 16 23 30	7 14 21 28	4 11 18 25	6 13 20 27	3 10 17 24 31
Mon.	Tu.	W.	Th.	F.	Sat.	Sun.	2 9 16 23 30	6 13 20 27	3 10 17 24 31	1 8 15 22 29	5 12 19 26	7 14 21 28	4 11 18 25
Tu.	W.	Th.	F.	Sat.	Sun.	Mon.	3 10 17 24 31	7 14 21 28	4 11 18 25	2 9 16 23 30	6 13 20 27	1 8 15 22 29	5 12 19 26
W.	Th.	F.	Sat.	Sun.	Mon.	Tu.	4 11 18 25	1 8 15 22 29	5 12 19 26	3 10 17 24 31	7 14 21 28	2 9 16 23 30	6 13 20 27
Th.	F.	Sat.	Sun.	Mon.	Tu.	W.	5 12 19 26	2 9 16 23 30	6 13 20 27	4 11 18 25	1 8 15 22 29	3 10 17 24 31	7 14 21 28
F.	Sat.	Sun.	Mon.	Tu.	W.	Th.	6 13 20 27	3 10 17 24 31	7 14 21 28	5 12 19 26	2 9 16 23 30	4 11 18 25	1 8 15 22 29
Sat.	Sun.	Mon.	Tu.	W.	Th.	F.	7 14 21 28	4 11 18 25	1 8 15 22 29	6 13 20 27	3 10 17 24	5 12 19 26	2 9 16 23 30

Leap-Years.

Dominical Letters and Initial Days (Leap Years)							Jan. 31 days, April 30, July 31	May 31 days	Feb 29 days, Aug 31	Mar 31 days, Nov. 30	June 30 days	Sept. 30 days, Dec 31	October 31 days
A.G.	G.F.	F.E.	E.D.	D.C.	C.B.	B.A.							
Sun.	Mon.	Tue.	W.	Th.	F.	Sat.	1 8 15 22 29	6 13 20 27	5 12 19 26	4 11 18 25	3 10 17 24	2 9 16 23 30	7 14 21 28
Mon.	Tue.	W.	Th.	F.	Sat.	Sun.	2 9 16 23 30	7 14 21 28	6 13 20 27	5 12 19 26	4 11 18 25	3 10 17 24 31	1 8 15 22 29
Tu.	Wed.	Th.	F.	Sat.	Sun.	Mon.	3 10 17 24 31	1 8 15 22 29	7 14 21 28	6 13 20 27	5 12 19 26	4 11 18 25	2 9 16 23 30
W.	Th.	F.	Sat.	Sun.	Mon.	Tu.	4 11 18 25	2 9 16 23 30	1 8 15 22 29	7 14 21 28	6 13 20 27	5 12 19 26	3 10 17 24 31
Th.	F.	Sat.	Sun.	Mon.	Tu.	W.	5 12 19 26	3 10 17 24 31	2 9 16 23 30	1 8 15 22 29	7 14 21 28	6 13 20 27	4 11 18 25
F.	Sat.	Sun.	Mon.	Tue.	W.	Th.	6 13 20 27	4 11 18 25	3 10 17 24 31	2 9 16 23 30	1 8 15 22 29	7 14 21 28	5 12 19 26
Sat.	Sun.	Mon.	Tu.	Wed.	Th.	F.	7 14 21 28	5 12 19 26	4 11 18 25	3 10 17 24 31	2 9 16 23 30	1 8 15 22 29	6 13 20 27

Fig. 3

Years by which the given Year exceeds the Hundreds of years.				Hundreds of years after Christ.			
				1700 2100 2500 2900 3300 3700	1800 2200 2600 3000 3400 3800	1900 2300 2700 3100 3500 3900	2000 2400 2800 3200 3600 4000
				C	E	G	A
1	29	57	85	B	D	F	G
2	30	58	86	A	C	E	F
3	31	59	87	G	B	D	E
4	32	60	88	E	G	B	C
5	33	61	89	D	F	A	B
6	34	62	90	C	E	G	A
7	35	63	91	B	D	F	G
8	36	64	92	G	B	D	E
9	37	65	93	F	A	C	D
10	38	66	94	E	G	B	C
11	39	67	95	D	F	A	B
12	40	68	96	B	D	F	G
13	41	69	97	A	C	E	F
14	42	70	98	G	B	D	E
15	43	71	99	F	A	C	D
16	44	72		D	F	A	B
17	45	73		C	E	G	A
18	46	74		B	D	F	G
19	47	75		A	C	E	F
20	48	76		F	A	C	D
21	49	77		E	G	B	C
22	50	78		D	F	A	B
23	51	79		C	E	G	A
24	52	80		A	C	E	F
25	53	81		G	B	D	E
26	54	82		F	A	C	D
27	55	83		E	G	B	C
28	56	84		C	E	G	A

Fig. 4. The DOMINICAL LETTERS for years from 1700 to 4000 A.D. New Style. 1st March to 28/29th February.

An Almanac for any Julian or Gregorian Year from 1st. March to 28/9th. Feby. following, except in such years as 1752 in which a calendrial change disturbs the ordinary sequence.

							Mar. 31 Nov. 30.	Apr. 30 July 31.	Aug. 31	Sep. 30. Dec. 31.	May 31. Jan. 31.	June 30. Feb. 28-9	Oct. 31.
D.	C.	B.	A.	G.	F.	E.	March. Feb.	April July Octr.	Aug. Novr.		May.	June Septr. Decr.	January.
S	M.	Tu.	W.	Th.	F.	Sat.	1 8 15 22 29	5 12 19 26	2 9 16 23 30	6 13 20 27	3 10 17 24 31	7 14 21 28	4 11 18 25
M	Tu.	W.	Th.	F.	Sat.	S.	2 9 16 23 30	6 13 20 27	3 10 17 24 31	7 14 21 28	4 11 18 25	1 8 15 22 29	5 12 19 26
Tu	W	Th.	F.	Sat	S.	M	3 10 17 24 31	7 14 21 28	4 11 18 25	1 8 15 22 29	5 12 19 26	2 9 16 23 30	6 13 20 27
W.	Th.	F.	Sat.	S.	M.	Tu.	4 11 18 25	1 8 15 22 29	5 12 19 26	2 9 16 23 30	6 13 20 27	3 10 17 24 31	7 14 21 28
Th.	F.	Sat.	S.	M.	Tu.	W.	5 12 19 26	2 9 16 23 30	6 13 20 27	3 10 17 24 31	7 14 21 28	4 11 18 25	1 8 15 22 29
F.	Sat.	S	M.	Tu.	W.	Th.	6 13 20 27	3 10 17 24 31	7 14 21 28	4 11 18 25	1 8 15 22 29	5 12 19 26	2 9 16 23 30
Sat.	S.	M.	Tu.	W.	Th.	F.	7 14 21 28	4 11 18 25	1 8 15 22 29	5 12 19 26	2 9 16 23 30	6 13 20 27	3 10 17 24 31

NOTE:—(1) That in this table the dates are in a continuous sequence throughout the table, whereas in Fig. 3 the monthly enumerations overlap twice.

(2) The above table serves for any year whether a common or a leap year.

(3) The months in the lower square give the almanac if August has 30 days and February 29/30 days.

Fig. 5

PART II

XI

CYCLES

OUR investigations must by this time have made it evident to the reader that the framers of calendars have a strong liking for cycles. The use of the cycle indeed plays a very important part in calendar construction. The month is a cycle of days, the year a cycle of days and also of months, and the week, standing apart from the other elements of the calendar, is itself a cycle of days. The week, however, is not itself a component of any larger cycle, and a very curious result of this difference must be pointed out. To be a component of a cycle confers identity on the component member. Every day is identified by enumeration of its position in the month; every month acquires an identity, or, if we might use the term metaphorically, a personality, in virtue of its position in the year. Similarly every day has an identity in respect of its position in the week. The week, on the other hand, not being a component of any larger cycle has no identity. No week is distinguished from another either by number or by name. They follow on in endless succession, each one passing nameless into the abyss of the past.

Not content, however, with these primary and fundamental cycles, calendar-makers, as we have already had occasion to note, have been largely occupied in designing longer cycles with years as their components. One of the earliest of these is that known in ancient times both in Chaldea and in Egypt—called in Egypt the Sothiacal or Canicular Period. It is vaguely referred to in a reported conversation between Herodotus and the priests of Egypt[1]. It comprised 1461 years of 365 days and consisted of an equation recording that these 1461 Egyptian years = 1460 solar, or as we should say, tropical years. The name is said to be a derivative from Sothis, the Egyptian name of Sirius, the dog star. The cycle began at a year when the heliacal rising of

[1] Herodotus, II, 142.

that star coincided with the summer solstice[1]. A cycle at any rate was held to have begun with 1322 B.C., because Censorinus—*De Die Natali*—mentions 238 A.D. as the hundredth year of the next cycle.

In Chaldea this cycle was known as the Nabonassarean Period, one of which was held to have commenced in 867 B.C.[2] The Chaldean astronomers also thought of a cycle of 473,040 years = 1460×18^2, which suggests that they were acquainted with the cycle of lunar eclipses commonly called the Saros. Owing to its freedom from intercalation the Nabonassarean year was a favourite with Hipparchus, Ptolemy and other ancient astronomers.

Another very important cycle was the Greek Olympiad, a cycle of four years, suggested by the quadrennial celebration of the Olympic Games at Olympia, a city of Elis. The Games were celebrated in July and the first Olympiad runs from 17th July, 776 B.C. The Games were held at the time of the first full moon falling after the summer solstice and the Olympiads were therefore computed from that date. The Greek months were lunar and were kept in relation with the solar year by the Metonic intercalations, the first month being that of the lunation next after the lunation in which the summer solstice occurred. That being so, the first month corresponded approximately with July. The marked difference of almost six months in the time of the commencement of the Olympiad year and the Julian year requires to be carefully attended to in dealing with chronological problems affected by the Olympiad. For example, when it is said that the first year of the Christian Era agrees with the first year of the 195 Olympiad it must be understood (as J. J. Bond points out) that the first six months of 1 A.D. correspond with the last six months of Olympiad 195, 1, and that the last six months of 1 A.D. correspond to the first six months of Olympiad 195, 2.

The Olympiad cycle is much used by historians of the time, but seldom or never in documents of state or inscriptions.

In 312 A.D. the Olympiads were officially superseded by the Roman Indiction of 15 years.

[1] Hales, *op. cit.* vol. I, p. 40. [2] As an era it was computed from 747 B.C.

The Metonic Cycle

Equal in fame, more widely distributed and of far more enduring value was the Metonic cycle, which we have already described, and which, being the expression of an important natural ratio between the lunation and the solar year, has been put in requisition from the earliest times up to the present day. Its use can be traced to an early date in China, and it constituted the basis both of the Jewish and of the Greek Calendar, as well as of the Ecclesiastical Calendar of the Christian states of Europe.

The term "Metonic Cycle" is properly applied to the cycle of 19 twelve-months reinforced by seven intercalary months, and is said to have been inaugurated by Meton in 432 B.C.

As 13th July, 432, was the commencement of the first Metonic cycle, it follows that the year from 13th July of 1 B.C. to 13th July of 1 A.D. was the XIVth year of a Metonic cycle. A new Metonic cycle therefore began on 13th July of 6 A.D. The twelve-month from 13th July, 29 A.D. to 13th July, 30 A.D. was thus number V of a Metonic cycle.

The Paschal Cycle

The cycle of $(19 \times 28) = 532$ years said to have been devised by Victorius (or Victorinus) of Aquitaine[1] was understood to have been published in 463 A.D. by Pope Hilarius.

It is said that the year 463 was treated as the Vth year of a cycle, whilst the second half of that year began the IInd year of a Metonic cycle—an unfortunate discrepancy which, however, need not detain us, as the lunar cycle which has been observed throughout the greater part of the Christian Era is that usually associated with the name of Dionysius Exiguus and said to have been introduced at his instance in 532 A.D. Under the rule of Dionysius a lunar cycle commenced with the last-mentioned year, which implies that the year 1 B.C. was the first of a 19-year cycle, 1 A.D. the second, and so on.

The cycle of 532 years was devised as the multiple of a lunar cycle of 19 years, and a solar cycle of 28 years, and was rightly

[1] Bucherius, whose work was a commentary on this cycle, calls him Victorius, but mentions (p. 90) that others call him Victorinus.

Table of the Golden Numbers for A.D. 1—A.D. 4000

(Either Old or New Style)

Hundreds of Years			Years less than a Hundred.																		
			0, 19, 38, 57, 76, 95	1, 20, 39, 58, 77, 96	2, 21, 40, 59, 78, 97	3, 22, 41, 60, 79, 98	4, 23, 42, 61, 80, 99	5, 24, 43, 62, 81	6, 25, 44, 63, 82	7, 26, 45, 64, 83	8, 27, 46, 65, 84	9, 28, 47, 66, 85	10, 29, 48, 67, 86	11, 30, 49, 68, 87	12, 31, 50, 69, 88	13, 32, 51, 70, 89	14, 33, 52, 71, 90	15, 34, 53, 72, 91	16, 35, 54, 73, 92	17, 36, 55, 74, 93	18, 37, 56, 75, 94
0	1900	3800	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
100	2000	3900	6	7	8	9	10	11	12	13	14	15	16	17	18	19	1	2	3	4	5
200	2100	4000	11	12	13	14	15	16	17	18	19	1	2	3	4	5	6	7	8	9	10
300	2200	—	16	17	18	19	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
400	2300	—	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	1
500	2400	—	7	8	9	10	11	12	13	14	15	16	17	18	19	1	2	3	4	5	6
600	2500	—	12	13	14	15	16	17	18	19	1	2	3	4	5	6	7	8	9	10	11
700	2600	—	17	18	19	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
800	2700	—	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	1	2
900	2800	—	8	9	10	11	12	13	14	15	16	17	18	19	1	2	3	4	5	6	7
1000	2900	—	13	14	15	16	17	18	19	1	2	3	4	5	6	7	8	9	10	11	12
1100	3000	—	18	19	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1200	3100	—	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	1	2	3
1300	3200	—	9	10	11	12	13	14	15	16	17	18	19	1	2	3	4	5	6	7	8
1400	3300	—	14	15	16	17	18	19	1	2	3	4	5	6	7	8	9	10	11	12	13
1500	3400	—	19	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1600	3500	—	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	1	2	3	4
1700	3600	—	10	11	12	13	14	15	16	17	18	19	1	2	3	4	5	6	7	8	9
1800	3700	—	15	16	17	18	19	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Fig. 6

judged as therefore containing within its limits a complete cycle of Easter dates. The 19 years of each lunar cycle were enumerated successively from 1 to 19, and the number which indicates the position of any particular year in one of these cycles is always called its Golden Number, a term borrowed from the nomenclature of the Metonic cycle. It must be kept in view, however, that this cycle was a mere record of a succession of years and did not include any scheme of months or monthly intercalations, its sole object being to indicate the ordinal position of the year with a view to determining the date of Easter. It is, therefore, unfortunate to describe this cycle as a Metonic cycle and it is best described as a lunar cycle.

The Solar Cycle

The so-called solar cycle of 28 years next requires notice. It is the other component of the Dionysian cycle of 532 years. It has received the name of the solar cycle for the reason that it has no reference to the motion of the moon, its only purpose being to ascertain the rule of the cyclical recurrent correspondence between the day of the month and the day of the week.

There being seven different days of the week, with any one of which the year may begin, and the length of a common year exceeding that of 52 weeks by one day, it follows that apart from the occurrence of leap year the correspondence between month-day and week-day would be repeated in a regular cycle of seven years. The occurrence of an extra day every fourth year has the unfortunate result that a period of 28 years is required to bring a repetition of the correspondence.

The framers of the Dionysian cycle of 532 years were obliged to provide the machinery necessary for utilising this 28-year cycle. For this purpose they introduced the use of the Dominical Letter and drew up a table showing all the relations of month-day and week-day. By convention the year 1 A.D. was made the 10th year of a solar cycle. The number of any year in the cycle can therefore be calculated by the following simple equation.

Take the date of the year A.D. add 9 and divide by 28. The remainder is its number in the solar cycle. If no remainder its number is 28.

The use of the Dominical Letter table has already been explained.

Indiction

The Indiction was a cycle of 15 years introduced by the Emperor Constantine in 312 A.D.—originally intended to be employed in connection with the public accounts and the collection of the imperial taxes.

Some years after its introduction the Nicene Council ordered it to be employed generally for purposes of chronology in place of the Olympiads. This enactment was conceived as an item in the general policy of christianising the order of civil society which naturally led the Council to substitute the period instituted by their patron Constantine for the earlier pagan style of reckoning by Olympiads.

Gibbon, ch. XIII, says: The name and use of the Indictions which serve to ascertain the chronology of the middle ages were derived from the regular practice of the Roman tribute. The Emperor subscribed with his own hand and in purple ink the solemn edict or indiction which was fixed up in the principal city of each diocese during two months previous to the 1st day of September; and by a very easy connection of ideas the word "Indiction" was transferred to the measure of the tribute which it presented and to the annual term which it allowed for the payment.

The Indiction as thus settled was computed to commence with 1st January, 313 A.D., and is usually called the Roman or Imperial Indiction. The Indiction has been long employed as the instrument of dating by the Papal Court. Under the Eastern Empire the principal taxation appears to have taken the form of an assessment on property based on an official valuation which was made at intervals of 15 years, and held good during the ensuing indictional period, subject, however, to the imposition of a super-indiction when deemed necessary. It follows that if the reckoning be carried back to the commencement of the Christian Era the year 1 A.D. would have been the year 4 of the current Indiction. Therefore, to find the position of a year in the indictional cycle, add 3 to the date and divide by 15, when the remainder will be the indictional number of the year.

XII

ERAS

Δός ποῦ στῶ καὶ χαριστίωνι τὰν γᾶν κινήσω πᾶσαν was the famous postulate of Archimedes, and the calendar-maker, no less than the mathematician, requires a *ποῦ στῶ*—some sort of starting point or fixed datum. Naturally for a long time, and whilst the creation of the world was believed to have been an almost instantaneous act, the date of that event would be regarded as the proper and obvious point of departure. The difficulty was to ascertain when the creation took place. So serious was this difficulty that, with the exception of the Jews, no other people seem to have adopted that event as the official origin of their chronology.

Evidently, however, some unique physical event would be the most satisfactory datum. An event of this description—even if subject to a periodic recurrence—provided only that its periodicity were sufficiently ample, would be ideal. A consciousness of this fact appears to have pervaded the minds of the early chronologers, and there are indications that the heliacal rising of some prominent star, such as Sirius or Arcturus, was at an early date, both in Chaldea and in Egypt, employed to supply the desideratum.

By the heliacal rising of a star is meant the date when after having been obscured by the light of the sun it first becomes visible in the East before sunrise.

Some other astronomical event might have served the same purpose but none such has proved suitable.

Olympiad. Recourse has generally therefore been had to the date of some civil historical occurrence conventionally selected. Thus we have the Era of the Olympiads, already referred to. That era began with the victory of Coraebus in the foot race at the Olympic Games—an event which occurred on 17th July in the year 776 B.C. The Games lasted five days from the 11th to the 15th days of the Attic lunar month Hecatombeon, which approximately corresponded to July. The Olympiads were formally superseded in the reign of Constantine and the Olympic

Games were abolished by Theodosius in 394 A.D. But in chronology the Era of the Olympiads is so frequently referred to that a knowledge of its limits is indispensable to historical students.

Throughout the greater portion of the time during which the Olympiads were in use the calendar was controlled by the rules of the Metonic cycle. The arrangement apparently worked smoothly, but the Olympiads only were employed in chronology.

The Era of Rome. Another important era was that by which the Romans reckoned, namely from the date of the supposed foundation of Rome. The dates of events in Roman history are usually indicated by reference to this starting point—the letters A.U.C., an abbreviation of *anno urbis conditae*, being employed to denote the reference. Notwithstanding the universal use of this datum by the Romans they differed as to the precise relation in which their initial date stood to the Olympiads. According to Polybius it corresponded with Olympiad VII, 3, which would identify it with 750 B.C., but the more generally accepted view is that ascribed to the erudite M. Terentius Varro, who identified it with Olympiad VI, 4 = 753 B.C. This date is supported by Cicero and Plutarch and is adopted by Censorinus[1]. It is now generally taken as the proper conventional commencement of the Era of Rome.

According to Varro and as confirmed by Plutarch in his *Lives of Romulus and Numa*, the foundation of Rome took place on 21st April, which date was also the birthday of Numa, the second and the greatest of Roman kings.

This therefore was the date from which the *Era of Rome* was computed. Mr Bond makes the curious mistake, again and again repeated, of confounding the date from which the era was computed with the date from which the calendar year was reckoned.

Era of Nabonassar. This early Chaldean era began with 747 B.C. = Olympiad VIII, 2[2]. A knowledge of this era is now of no value unless to those specialists who study the chronology of antiquity. It was of high importance in an age and to a civilisation once great and powerful though now remote and little known. It need not therefore further detain us.

[1] *De die Natali*, c. 21.

[2] In this year Nabonassar overthrew the Assyrian Empire and founded the Babylonian.

In early times various other eras enjoyed a short and partial observance, such as the Era of Alexander the Great, the Era of Tyre, etc. These need not be described.

The Julian Era or date of the institution of the Julian Calendar might very fairly have been adopted as a starting point, but there is but scant evidence of its employment, the Era of Rome having retained its office as the initial date for some considerable time after the establishment of the Julian Calendar. Evidently Caesar, with his usual sagacity, discouraged any change not required to make his great reform complete and effective.

Another not inappropriate date was afforded by the Battle of Actium, which signalised the virtual establishment of the Roman empire. There are traces of the use of this date under the name of the Era of Augustus, but its adoption was never complete or widespread.

For a short time the Christian Church treated the memorable persecution under Diocletian as an era date from which events were reckoned and which corresponded to 284 A.D. Prior to the short-lived use of this era the early Christians sometimes employed the Alexandrian Era, which drew back to a supposed Creation date, though it cannot claim a truly ancient Egyptian usage.

The Jewish Era. The commencing era employed when the Jewish Calendar was in use, was the supposed date of the Creation. This event in the Jewish calendar is assumed to have happened 3761 years or 3760 years and three months before the 1st January of 1 A.D. The Jewish civil year began with the month Tisri, the commencement of which coincided as nearly as possible with the autumnal equinox.

In India an era known as the Kaliyug has been employed, its assumed commencement being the year 3102 B.C.

In China the commencing date seems to have been 2397 B.C.

In the chronology of Bishop Usher, which has been widely popular in modern times in England, the Creation date is taken as 4004 B.C., but this date has never been utilised as an era to reckon from.

Perhaps the curious student may be able to discover some general principle to account for so widespread a disposition to

refer the Creation to a date some 3000–4000 years prior to the commencement of our era. Several eras seem to draw back to the date of the Deluge—the traditional belief in which was widely distributed in the countries adjacent to the Eastern Mediterranean.

The Christian Era. This era will be dealt with in the following section.

Era of the Hegira. The Era of the Hegira is the only other era which we require to mention. The Mahometan Lunar Calendar is computed to have commenced with 16th July, 622 A.D., the Prophet's flight having taken place on the preceding evening.

XIII

THE CHRISTIAN ERA

The custom of computing dates from the Incarnation did not come into use until a considerable time after the foundation of the Christian Church.

Its introduction is usually attributed to Dionysius Exiguus (Denis le Petit), said to have been a Scythian monk and Abbot of Rome early in the sixth century, who was also credited with the establishment of the Easter cycle of 532 years.

The generally accepted account of Dionysius is taken from the great chronological work of the Benedictines, *L'Art de vérifier les dates*, from which it is copied without comment into cyclopaedias and books of reference. Mr F. A. Arbuthnott, in *Mysteries of Chronology*, states that it was seriously questioned by a Jesuit Father Hardouin in a work on the chronology of the Old Testament about two hundred years ago, and may probably be to some extent fictitious. It seems doubtful if there was in the sixth century any such office as Abbot of Rome, but Mr Arbuthnott was not fully informed as to Dionysius and seemed ignorant of the account given by Petavius[1].

[1] Petavius records the text of a letter by Dionysius to a bishop named Petronius as follows: "Quia vero Sanctus Cyrillus primum cyclum ab anno Diocletiani 153 coepit et ultimum in 247 terminavit; Nos a 248 anno ejusdem tyranni potius quam principis inchoantes noluimus circulis nostris memoriam impii et persecutoris innectere; sed magis elegimus ab incarnatione Domini Nostri Jesu Christi annorum tempora praenotare; quatenus exordium Spei nostrae notius nobis existeret, et causa reparationis humanae, id est passio Redemptoris nostri evidentius eluceret." Petav. II App. p. 498.

There is no harm in assuming that someone named Dionysius early in the sixth century took in hand the adjustment of the Easter cycle of 532 years, already invented by Victorius of Aquitaine. His object seems to have been to make the first cycle start from the date of the Incarnation, and thus incidentally he was credited with the introduction of Incarnation datings. No otherwise can we justify his alteration of the chronological position of the lunar cycle which had hitherto been treated as a consecutive continuation of the Metonic cycle. At any rate, if the common story is to be accepted, something like this was what he did. He made the year we now call 532 A.D. the first of a new cycle, thus making 1 B.C. (which he took to be the year of the Incarnation) to be the commencing year of the first Easter cycle of 532 years.

In arriving at the date of the Incarnation Dionysius is understood to have accepted the widespread tradition that Christ was born in the 28th year of the reign of Augustus. This is the statement of Clement of Alexandria[1].

Dionysius, however, fell into error in computing the commencement of that reign which he assumed to be 727 A.U.C., the year in which Octavius adopted the name or title of Augustus, whereas in point of fact his reign was always computed from the date of the Battle of Actium, 2nd September, 723 A.U.C. (= 31 B.C.). The position can be best understood by reference to a tabular statement of corresponding dates commencing with the Battle of Actium and which we here subjoin.

2nd Sept. 723 A.U.C.	= date of the Battle of Actium.
Sept. 723–Sept. 724	= 1st year of Augustus.
∴ Sept. 750–Sept. 751	= 28th year of Augustus.
∴ 25th Dec. 750	= Birth of Christ = 4 B.C.
1st Jan. 751–31st Dec. 751	= 1 Anno Christi = 3 B.C.
1st Jan. 754–31st Dec. 754	= 4 Anno Christi = 1 A.D.

Date of Nativity

Valuable assistance in ascertaining the probable date of the Incarnation is derived from the chronology of Herod the Great, as recorded by Josephus.

[1] *Stromata*, I, 21.

The cardinal data are:

(1) That Christ was born during the reign of Herod.

(2) That Herod died during the infancy of Christ.

Now Josephus states[1] that Herod died in the 34th year of his reign, counting from the death of his rival, Antigonus, and the 37th year counting from his nomination as king by the Roman Senate.

Again Josephus states[2] that the Battle of Actium was fought in the seventh year of Herod's reign. Commentators are agreed that in reckoning the dates of events during Herod's reign Josephus always computed these from the death of Antigonus, and consequently he died $34 - 7 = 27$ years after Actium, *i.e.* he died 750 A.U.C. = 4 B.C. Christ's birth was therefore shortly before that date.

Josephus also tells us that Herod died shortly after a lunar eclipse, presumably that which occurred on 13th March, 750 A.U.C., and that he died before the following Passover, and therefore in the latter half of March, 750 A.U.C.

(Care must be taken to distinguish between Herod the Great who reigned at Jerusalem over an extensive area, and Herod Antipas, who after his death was tetrarch of Galilee and was present at Jerusalem at the time of the Crucifixion.)

It is pointed out by Hales that the chronology of Philip, who succeeded Herod the Great in the office of tetrarch of Iturea, confirms the date of the death of Herod the Great as having been 750 A.U.C., because Josephus states that Philip died in the 20th year of Tiberius, after governing Trachonitis 37 years. This brings the beginning of his reign to 750 A.U.C.[3]

Further light as to the date of the Nativity is sought for from the passage in Luke ii, 1 and 2:

> And it came to pass in those days, that there went out a decree from Caesar Augustus, that all the world should be taxed. (And this taxing was first made when Cyrenius was governor of Syria.) And all went to be taxed, every one into his own city.

Josephus[4] informs us that a taxing by Cyrenius was finished in the 37th year of Caesar's victory over Antony at Actium.

[1] *Antiq.* XVII, 8. *Bell. Jud.* I, 23, 8.

[2] *Antiq.* XV, 5, 2.

[3] Josephus, *Antiq.* XVIII, 4, 6.

[4] *Antiq.* XVIII, 2.

Now we have seen that according to Josephus Herod the Great died 27 years after Actium. Thus it would seem that the taxing under Cyrenius took place 10 years after the death of Herod. The explanation which has usually been given is that the Decree by Augustus was not enforced or completed for 10 years, although when the Decree was promulgated everyone attended in his own native city for the purpose of enrolment. After the death of Herod, his son Archelaus assumed the sovereignty of Judea and reigned 10 years in Jerusalem, when he was deposed by Augustus, and Cyrenius was appointed to sequestrate his estates and administer the province. There is no improbability in the view that the actual taxation postponed during the misgovernment of Archelaus was levied by Cyrenius 10 years later. The clause in Luke referring to Cyrenius seems to suggest a distinction between the date of the Decree by Augustus and the collection of the tribute by Cyrenius. This view, according to Hales, is supported by Justin Martyr, Julian the Apostate and Eusebius. Tertullian is said to place the first enrolment in the 33rd year of Herod's reign, *i.e.* B.C. 5.

If the above explanation be sound it is quite consistent with the date of 4 B.C. for the Nativity.

Recent discoveries of papyri in Egypt show that a census was taken there at intervals of 14 years. At a later date the indiction of 15 years corresponded to such periodic taxations. These papyri prove that the year 20 A.D. was the date of such a census, going back from which date brings us to 6 A.D., thus confirming the statement of Josephus[1]. Another interval of 14 years takes us back to 9 B.C. Inscriptions found recently in Asia Minor support the view that Cyrenius held a high military office in Pisidia about 8 B.C. It is suggested therefore that the date of the Nativity must be carried back to that year. It is, however, not clear that Cyrenius was governor—*ἡγεμών*—of Syria then. There is moreover no proof that any census or enrolment was carried out in Syria before the 28th of Augustus = 750 A.U.C.[2] Josephus (XVIII, cap. 1) expressly tells us that after the fall of

[1] But a census at Rome under Augustus was completed in 14 A.D.

[2] Clement of Alexandria states that a census was first ordered to be taken in that year.

Archelaus "Cyrenius came at that time to Syria, being sent by Caesar to be a Judge of that Nation, and to take an account of their substance." After mentioning that Coponius was sent with him to have supreme power over the Jews, he goes on, "Moreover Cyrenius came himself into Judea, which was *now* added to the province of Syria, to take an account of their substance, etc." On the whole it looks as if Luke had in his mind the census made or at least finished in 6 A.D., and that his parenthetical sentence was intended to connect the taxation completed then with an earlier enrolment. Luke certainly does not say that Cyrenius was Governor of Syria when Joseph and Mary went to Bethlehem, and the question cannot be regarded as settled without definite evidence as to the date of the Decree of Augustus and the subsequent enrolment in Judea. It can hardly be affirmed with confidence that the evidence of these inscriptions is sufficient to upset the definite statement of Matthew that the massacre of the innocents took place during the infancy of Christ. It seems as likely that Luke writes loosely as to the census, or that his text is in some word corrupt. Moreover the traditional view, as we may call it, is supported by early extant writings of the fathers and the fact of the massacre of the innocents, though not referred to by Josephus, is confirmed by Macrobius[1], and also by a rabbinical work, *Toldoth Jeshu*; although the latter is admittedly not a reliable authority[2]. These computations cannot be exact to a year without more precise knowledge than we possess as to the day and month from which the commencement of the year was reckoned by different writers, and the exact date of the death of Antigonus—but they obviously confirm the view that Dionysius made a mistake of at least 3–4 years.

According to the chronology now for so many centuries adopted by historians and chronologers, Christ was born on 25th December of 1 B.C., and the following (Saturday) 1st January was the first day of 1 A.D.[3] Astronomers, however, are

[1] *Saturnalia*, II, 40.

[2] The whole subject is fully discussed in Professor Ramsay's work, *The Bearing of Recent Discovery on the Trustworthiness of the New Testament*.

[3] By this reckoning the interval between any date in, say, 100 B.C. and the same date in 900 A.D. is—not 1000 but 999 years.

in the habit of treating the actual year of Christ's birth as a zero year or 0 A.D. and calling 1 B.C. the year previous. This difference of reckoning has given rise to considerable trouble and some confusion, but in the meantime both parties adhere to their own method of computation. Professor De Morgan, for example, adopts the astronomers' reckoning in his *Book of Almanacs*. As a mathematician he naturally inclined to the astronomers' method. In certain cases chronological problems of nicety are further complicated by the astronomers' rule of commencing their day with noon, whilst chronologers, historians and the civil population generally begin it at midnight. The difference of method in reckoning the year of the Nativity gave rise or at least gave colour and encouragement to the disputes which in 1800 and again in 1900 took place as to whether these years were the last of the old or the first of the new century. Under the astronomers' rule the latter view seemed entitled to more support than it received.

Date of the Crucifixion

Indirectly the settlement of the date of the Crucifixion has also a bearing on that of the Nativity. It has a more important bearing on some of the questions which have been agitated as to the date of Easter. The problem may be best presented under successive stages.

I. It must be accepted as beyond all question that "Christ suffered under Pontius Pilate." The Gospel narratives by themselves leave no room for doubt, and they are supported by the absolutely independent statement of Tacitus[1] that Jesus suffered death in the reign of Tiberius under the procurator Pontius Pilate, and also by Josephus[2].

II. Now we have it on the authority of Josephus[3] that Pontius Pilate's tenure of the office of procurator of Judea corresponded with the last 10 years of Tiberius's reign, *i.e.* from 27–37 A.D. These then are the limits within which the year of the Crucifixion must be found.

III. We have the fact that Christ was crucified on the day after he had eaten the Passover with his disciples. The state-

[1] *Annals*, XV. [2] *Antiq.* XVIII, 3. [3] *Antiq.* XVIII, 4, 2.

ments of Matthew xxvi, 17, 19; Mark xiv, 12; Luke xxii, 7, and John xiii, 1, are on this point unanimous. The suggestion that they are all wrong, and that the Last Supper was not the Passover Feast, seems to be too far fetched to be tenable.

IV. The Paschal Lamb was eaten in the first month on the 14th day of the month at even (Exod. xii, 6; Leviticus xxiii, 5, 6–14).

V. The Jewish months were lunar and commenced with the first visibility of the new moon, probably a day after the actual conjunction. The 14th day of the moon was therefore generally the day of *full moon*.

The Jewish day ran from sunset to sunset, and it might therefore be supposed that on a strict interpretation of the text the Paschal Lamb was eaten on what we should call the evening of the 13th day or just after the 14th day, by Jewish reckoning, had begun. In point of fact, however, the evening of the 14th day meant the afternoon of that day—the interval from about 3 p.m. to sunset—just before the close of that day.

That this is the true interpretation is shown by Levit. xxiii, 27:

> Also on the tenth day of this seventh month there shall be a day of atonement.

The 10th of Tisri is observed as the great day of atonement. Now verse 32 is as follows:

> It shall be unto you a Sabbath of rest, and ye shall afflict your souls: in the ninth day of the month at even, from even unto even, shall ye celebrate your Sabbath.

This Sabbath was the 10th of Tisri. It would seem, therefore, that the expression by which they referred to the evening with which the 10th day began was the ninth day at even. By analogy the words "On the 14th day of the month at even," would mean the evening at the close of the 14th day.

> Again Exodus xii, 18 reads: "In the first month, on the fourteenth day of the month at even, ye shall eat unleavened bread, until the one and twentieth day of the month at even."

Now if in this verse it were meant the even with which the one and twentieth day began, that reading would exclude the whole of that day. Such a result would be directly contrary to Levit. xxiii, 6, in terms of which the feast of unleavened bread

began on the 15th and continued seven days, thus including the 21st[1]. Moreover, Josephus[2] expressly states that the second day of unleavened bread was the 16th of the month.

VI. The day of the Crucifixion is stated by all the four Gospels[3] to have been the preparation, παρασκευή, the common name for Friday, the day before the Jewish Sabbath. It is true that St John calls it "the preparation of the Passover." Some commentators have supposed that that expression means a day precedent or preparatory to the Passover. But there is no trace of such a day in the Jewish ritual[4]. The preparation of the Passover was simply a familiar description of the particular Friday which chanced to fall at the celebration of the Passover, pretty much as we speak of "Easter Monday." Each of the synoptic Gospels speaks simply of the preparation of the Sabbath. Moreover there can hardly be any doubt that the day following was a Sabbath, and that the next day, being the third according to the ancient inclusive reckoning, was the first day of the following week. There can therefore be no reasonable doubt that the Crucifixion took place on a Friday.

Great difficulty has been found in the statement in John xviii, 28:

> Then led they Jesus from Caiaphas unto the hall of Judgment: and it was early; and they themselves went not into the judgment hall, lest they should be defiled; but that they might eat the Passover.

This verse has led to an immense amount of dispute and discussion. It apparently implies that the High Priests ate the Passover a day later than Jesus and his disciples. Innumerable explanations have been offered, *e.g.* (*a*) that the Last Supper was not a Passover, a view which we set aside as quite untenable; (*b*) that there was at Jerusalem a stricter sect who computed the new moon as at the actual time of conjunction, to which sect Christ adhered, and a popular sect who computed it as at the first visibility of the crescent, to which Caiphas be-

[1] This argument is frequently advanced by Bede in his *Ecclesiastical History*.

[2] *Antiq.* III, 10, 5.

[3] Matt. xxvii, 62; Mark xv, 42; Luke xxiii, 54; John xix, 31.

[4] Mark xv, 42 expressly defines the preparation as the day before the Sabbath.

longed; (*c*) that owing to weather conditions there was on that occasion doubt as to the exact day of first visibility—a thing which actually happened so often that special provision was made for it in the Jewish Calendar. This view seems to be more likely.

The difference may have been, to some extent, responsible for the feud between the Quartadecimans and the Quintadecimans which convulsed the Church in the fourth century, and which possibly arose out of the discrepancy in question, though its entire complexion soon underwent a change.

The difficulty of course may be due to some mere clerical error or obscurity in the Gospel MSS. At any rate it need not detain us for it cannot be allowed to disturb the clear and consistent evidence of all the other authorities as to the day when Christ ate the Passover and the day on which he died. With these data the question resolves itself into the astronomical problem: To find in which year between 27 and 37 A.D. the first full moon after the vernal equinox fell on a Thursday. With this problem the astronomers have wrestled long. Hales, with the astronomical evidence before him, favoured 31 A.D. James Ferguson, a very sound and careful astronomer and chronologer, selected 33 A.D.[1]. But the bulk of astronomical opinion most strongly favours 30 A.D. In that year it is said a new moon would probably have been visible on the evening of 23rd March. The day we call 24th March would therefore be the 1st of Nisan. The 14th Nisan would be Thursday, 6th April, and the Crucifixion, Friday, 7th April, 30 A.D.[2].

This would make the age of Jesus, assuming he was born in 4 B.C., between 33 and 34 years, which entirely harmonises with the statement of Luke that at his baptism by John he began to be about 30 years old, supplemented by the generally accepted view that his public ministry thereafter lasted rather over 3 or $3\frac{1}{2}$ years[3].

[1] An ancient tradition that Christ was crucified on 25th March, 29, has long received credence; but in 29 A.D. Nisan 14 fell on Sunday, 17th April, the previous full moon being prior to the equinox.

[2] See *Journal* of British Astronomical Association, vol. XXI, p. 360; also Bond's *Handy Book*, pp. xxxvi, 22, 222.

[3] Luke states that the baptism of Jesus took place in the fifteenth year of

Although there seems reason to accept the view that the idea of the Christian Era was first suggested in connection with the readjustment of the Easter cycle by Dionysius in 532 A.D., it was several centuries later before the use of Incarnation datings became at all general. The earliest or one of the earliest to employ them was the Venerable Bede of Jarrow, a man whose influence on the Continent was far greater than is usually supposed, and who employed them in his *History of England*, written in the first quarter of the eighth century. It is to him that we owe the actual date of 1 A.D. Assuming that the Nativity took place on 25th December, 753 A.U.C., he treated the year 754 A.U.C. as 1 A.D. This is the accepted rule, the assumed date of the Nativity being 25th December of the year *before* 1 A.D., called by chronologers 1 B.C. and by astronomers 0 A.D..

XIV

THE JULIAN PERIOD

Amidst the varieties of cycles and eras it occurred to the celebrated Joseph Scaliger to devise a period sufficiently comprehensive to furnish a general standard of reference for one and all of them.

He might have taken the period of 25,868 years, which covers one complete revolution of the equinoctial points.

He proposed, however, what he called the Julian Period (P. J.) of 7980 years.

This figure is the multiple of 19 (the Metonic cycle), 28 (the so-called solar cycle) and 15 (the Indictional cycle).

He found that by carrying each of these cycles back a commencement of each of them would coincide with the year 4713 B.C. This happy coincidence determined him. The 1st January of the year 4713 B.C. he made the beginning of his period, which will not be complete until 3267 A.D.

Scaliger's great work, *De Emendatione Temporum*, seems to have been written mainly with the design of introducing this

Tiberius. Reckoning from the death of Augustus, that would be 29 A.D., but Luke probably computed the years of Tiberius from the date of his association with Augustus in the imperial offices in 12 A.D.

universal period to chronology, and the highest praise has been awarded to the utility of the idea by subsequent chronologers and astronomers. The period was fixed to commence at 1st January, and the rule of the Julian Period thus furnishes us with reason for resisting any proposal to change the date of commencement of the year as an instrument of dating. Few things have more perplexed chronologers and interfered with the simplicity of calendars than the endless variations in the date of commencement of the dating year. This in no way, however, obliges us to employ 1st January as the beginning of the year in reckoning legal or commercial intervals of time or in adjusting the tables of the solar or Metonic cycles.

PART III

XV

THE DATE OF EASTER

THE festival of Easter which commemorates the death and resurrection of Jesus Christ has, from the earliest Christian times, been the most important in the Christian Calendar. The question of the proper date of its observance for centuries agitated the religious community in many portions of Christendom. Primarily the determination of the date depends upon that of the Passover—the most ancient festival of the Jewish religion—which to-day can claim a longer unbroken lineage than almost any other human institution. The Passover commenced with the eating of the Paschal Lamb at the Paschal Supper on the evening of the fourteenth day of the moon of the month Nisan. Nisan is the first month of the Jewish sacred or ecclesiastical year, which was computed to begin at or about the vernal equinox, and the full moon of the Passover is the first full moon falling on or after the vernal equinox. The Hebrew months being lunar and intercalation being therefore necessary to maintain the lunar twelve-month in a constant relation with the seasons of the tropical year, a certain amount of oscillation was inevitable in the date of commencement of the first month of the year. "The first month of the luni-solar year by reason of the intercalary month began sometimes a week or a fortnight before the Equinox (or Solstice) and sometimes as much after it[1]." It consequently often happened that the new moon of Nisan fell before the vernal equinox, but the intercalations were so arranged that the fourteenth day of that moon was always subsequent to the equinox. Christ and his disciples celebrated the Paschal Supper on a Thursday evening. Christ was crucified on the following Friday and the Resurrection took place on the

[1] Sir Isaac Newton's *Chronology*, p. 82.

third day thereafter which, according to the ancient rule of inclusive computation, was the first day of the following week.

The three synoptic Gospels are most explicit in their statement that Christ ate the Passover on the day prior to his Crucifixion. A passage in the Gospel of John, xviii, 28, suggests that the High Priests were to celebrate the Passover on the Friday. No generally accepted explanation is available to account for the difference of date, and the discordance led to an incredible amount of discussion and dispute in the early centuries of our era.

Two parties, named respectively Quartadecimans and Quintadecimans, divided the ecclesiastical arena. It would be difficult, and is happily unnecessary, to follow the controversy in detail. Originally it perhaps arose out of the difference above referred to between the day observed by Christ and that said to have been observed by Caiaphas. But to judge from the terms of Abbot Ceolfrid's letter on the rules for the keeping of Easter quoted by Bede[1], as well as from several remarks by Bede himself, it hinged upon the question whether the evening of the fourteenth day meant the afternoon of that day or the previous evening, when—according to the Jewish custom of reckoning from sunset to sunset—the fourteenth day had begun[2]. The former was the Quintadeciman, the latter the Quartadeciman view. The letter in question is an interesting statement of the Quintadeciman case. The Greek or Eastern Church supported the Quartadecimans, who were represented by Polycrates, Bishop of Ephesus; whilst Victor, Bishop of Rome, supported the Quintadecimans. Latterly the controversy altered to a dispute as to whether the Easter festival should be celebrated on the actual anniversary of the Passover or as a Memorial of the Resurrection on the following Sunday. By supporting this latter view the Quintadecimans retaliated on the charge of judaising originally brought against them by their opponents. The question was finally decided by the Nicene Council in favour of the revised Quintadeciman doctrine. The Christian Church in Britain, which was originally Quartadeciman, was then out of

[1] *Ecclesiastical History*, book v, chap. xxi.

[2] See Sect. xiii, *ante*, p. 56.

touch with the Continent, and when Roman missionaries reappeared in the sixth century it was not without controversy and bloodshed that the Celtic Churches were ultimately persuaded or compelled to abandon the Quartadeciman rule.

The history of the dispute has some chronological value, but need not occupy more space in a survey of calendrial problems. The terms of the Nicene Decree were long supposed to be lost, but the purpose and effect of the decision have been traditionally transmitted, and the recent recovery of the text has not thrown any substantial doubt on the accuracy of the accepted interpretation of the Nicene rule of practice. The alleged text of the Decree[1] does not expressly specify the date of Easter, but simply enjoins the brethren of the Eastern Church to conform to the rule observed by Rome and Alexandria. The practice of these Churches was well known, so that there can be little doubt as to the purpose of the Council.

Although this may not have been expressly defined in the text of the decree, it is admitted that the date of the Resurrection was the first day of the week which immediately followed that in which the Passover was celebrated. To avoid the suspicion of judaising it was agreed that Easter should never coincide with the Passover date, but should be observed on the subsequent Sunday. Thus the rule was adopted that Easter should be the first Sunday *after* the first fourteenth day of the moon falling on or after the vernal equinox.

It was generally assumed by the ecclesiastical authorities for many centuries after 325 A.D. that the date of the vernal equinox of that year was 21st March. It was said (by the late Professor Millosevitch) that the fathers of Nicea ascertained the true date of the occurrence by means of gnomons. This is quite probable, although, in point of fact, the actual hour of its occurrence in 325 A.D. appears to have been some time in the evening of the 20th. Owing, however, to the fact that the Julian Calendar assumed the length of the year to be 365 days 6 hours, which exceeded the true length of the tropical year by 11 minutes 14 seconds, the equinox fell annually by that amount earlier in the calendar. As time passed an ever-widening interval

[1] See Pitra, *Spicilegium Salesmense*, tome IV, p. 541.

separated the actual date from the 21st March, and the object of the Gregorian reform was to provide a solution of the difficulties and disputes which thence arose.

Meantime we have to explain how the date of this movable festival is ascertained in practice. The leaders of the early Church manifested a strong desire to discover a cycle of years within the limits of which the dates of Easter would repeat themselves in the same order. It is probable that their knowledge of the Metonic cycle—in which the dates of new and full moons repeated themselves in 19 years—first suggested to their minds the desirability of seeking a cycle of Easter dates. The establishment of such a cycle would also facilitate the determination of Easter, and might ensure a general agreement as to its proper date. Be that as it may, there is no doubt that the search for a cycle was prosecuted with vigour for several centuries. It is unnecessary to describe the several very inaccurate, imperfect and purely empirical cycles which were from time to time proposed. Most of these were multiples of the lunar cycle of 19 years. Such, for example, as a cycle of $19 \times 23 = 437$ years proposed by Theophilus of Alexandria, and the cycle of $19 \times 5 = 95$ years proposed by Cyril of Alexandria in 412 A.D., and which appears to have been much admired. In outlying portions of the Western Church during the early part of the fifth century a Quartadeciman cycle of 84 years ($19 \times 4 = 76 + 8$) was employed.

The date of the vernal equinox having been assumed fixed on 21st March, the two variables on which Easter must depend were (1) the lunar cycle of 19 years, and (2) the so-called solar or dominical cycle of 28 years. It follows that the proper cycle is one of $19 \times 28 = 532$ years. Such a cycle is said to have been constructed by an ecclesiastic named Victorius or Victorinus of Aquitaine and to have been adopted by Pope Hilarius in 463. A subsequent change in the date of commencement of the cycle, attributed to Dionysius Exiguus, was made about 532, and the cycle thus adjusted was thereafter employed for the determination of the Easter date up to the time of the Gregorian reform[1].

[1] The first year of the Dionysian cycle corresponds to the fourteenth of the Metonic and the seventeenth of the cycle of Victorinus or Hilarius.

The Easter dates for this period of 532 years were computed from 1 B.C., and these having been ascertained and recorded, any one in possession of such a record was equipped with a table valid for an indefinite period.

We must now explain how the dates to be so recorded were ascertained.

In the first place it is necessary to prepare a Perpetual Lunar Calendar, that is to say to take a skeleton almanac of monthly dates on which are noted at their respective days the 235 days on which a new moon would fall during the cycle of 19 years. Starting with the ascertained date of the new moon of January in the first year of the Metonic cycle the subsequent moons are entered at intervals of 29 and 30 days alternately. These being the moons of the *first* year of the cycle the number I is entered against the days on which they occur. The moons of the next year occur 11 days earlier. Therefore, 11 days earlier the number II is entered at the respective dates, and so on until the whole 235 new moons of the cycle have been recorded in their appropriate positions, under the heading "Golden Numbers." This being done it will be found that those years of the cycle in which Meton introduced an embolismic month (*viz.* the 3rd, 5th, 8th, 11th, 13th, 16th and 19th) contain 13 new moons. In the annexed Lunar Almanac (adapted from that in *L'Art de vérifier les dates*) the first new moon of the first year falls on 23rd January and the first of the third year on the 1st January[1]; and the seven thirteenth or intercalary new moons and the seven embolismic months of 30 days which start from them are identified with the following:

IIIrd	year	21 Dec.–19 Jan.			XIIIth	year	31 Dec.–29 Jan.		
Vth	,,	29	,,	–27 ,,	XVIth	,,	28	,,	–25 ,,
VIIIth	,,	26	,,	–24 ,,	XIXth	,,	24	,,	–22 ,, [2]
XIth	,,	23	,,	–21 ,,					

The annexed table of a Perpetual Lunar Almanac shows the positions of the new moons in each year of a cycle, and during

[1] The G.N. dates are those in the Julian calendar; the Epact dates are Gregorian.

[2] This lunation in the Metonic cycle was 29 days and would thus end on 21st January; but the next lunation of G.N. I commences on 23rd January.

Perpetual Lunar Almanac.

January				March					May			
Days of Month.	Golden Numbers	Dominical Letters	Epact	Days of month	Golden Numbers	Dominical Letters	Epact	Paschal Term.	Days of Month	Golden Numbers	Dominical Letters	Epact.
1	III.	A	*	1	III	D	*		1	XI.	B	28
2	O	B	29	2	O	E	29		2	O	C	27
3	XI.	C	28	3	XI	F	28		3	XIX.	D	26
4	O	D	27	4	O	G	27		4	VIII.	E	25. XXV.
5	XIX.	E	26	5	XIX.	A	26		5	O	F	24
6	VIII.	F	25. XXV.	6	VIII.	B	25. XXV.		6	XVI.	G	23
7	O	G	24	7	O	C	24.		7	V.	A	22
8	XVI.	A	23	8	XVI.	D	23	Mar. 21	8	O	B	21
9	V.	B	22	9	V.	E	22	22	9	XIII.	C	20
10	O	C	21	10	O	F	21	23.	10	II.	D	19
11	XIII.	D	20	11	XIII.	G	20	24.	11	O	E	18
12	II.	E	19	12	II.	A	19	25.	12	X.	F	17
13	O	F	18	13	O	B	18	26.	13	O	G	16
14	X.	G	17	14	X.	C	17	27.	14	XVIII.	A	15
15	O	A	16	15	O	D	16	28.	15	VII.	B	14
16	XVIII.	B	15	16	XVIII.	E	15	29	16	O	C	13
17	VII.	C	14	17	VII.	F	14	30	17	XV.	D	12
18	O	D	13	18	O	G	13	31.	18	IV.	E	11
19	XV.	E	12	19	XV.	A	12	Apr. 1.	19	O	F	10
20	IV.	F	11	20	IV.	B	11	2.	20	XII.	G	9
21	O	G	10	21	O	C	10	3.	21	I.	A	8
22	XII.	A	9	22	XII.	D	9	4.	22	O	B	7
23	I.	B	8	23	I.	E	8	5.	23	IX.	C	6
24	O	C	7	24	O	F	7	6.	24	O	D	5
25	IX.	D	6	25	IX.	G	6	7.	25	XVII.	E	4
26	O	E	5	26	O	A	5	8.	26	VI.	F	3
27	XVII.	F	4	27	XVII.	B	4	9.	27	O	G	2
28	VI.	G	3	28	VI.	C	3	10.	28	XIV.	A	1
29	O	A	2	29	O	D	2	11.	29	III.	B	*
30	XIV.	B	1	30	XIV.	E	1	12.	30	O	C	29
31	III.	C	*	31	III.	F	*	13.	31	XI.	D	28

February				April					June			
1	O	D	29	1	O	G	29.	Apr. 14.	1	O	E	27
2	XI.	E	28	2	XI.	A	28	15.	2	XIX.	F	26. XXV.
3	XIX.	F	27	3	O	B	27	16.	3	VIII.	G	25. 24
4	VIII.	G	26. XXV.	4	XIX.	C	26. XXV.	17.	4	XVI.	A	23
5	O	A	25. 24	5	VIII.	D	25. 24	18.	5	V.	B	22
6	XVI.	B	23	6	XVI.	E	23		6	O	C	21
7	V.	C	22	7	V.	F	22		7	XIII.	D	20
8	O	D	21	8	O	G	21		8	II.	E	19
9	XIII.	E	20	9	XIII.	A	20		9	O	F	18
10	II.	F	19	10	II.	B	19		10	X.	G	17
11	O	G	18	11	O	C	18		11	O.	A	16
12	X.	A	17	12	X.	D	17		12	XVIII.	B	15
13	O	B	16	13	O	E	16		13	VII.	C	14
14	XVIII.	C	15	14	XVIII.	F	15		14	O	D	13
15	VII.	D	14	15	VII.	G	14		15	XV.	E	12
16	O	E	13	16	O	A	13		16	IV.	F	11
17	XV.	F	12	17	XV.	B	12		17	O	G	10
18	IV.	G	11	18	IV.	C	11		18	XII.	A	9
19	O	A	10	19	O	D	10		19	I.	B	8
20	XII.	B	9	20	XII.	E	9		20	O	C	7
21	I.	C	8	21	I.	F	8		21	IX.	D	6
22	O	D	7	22	O	G	7		22	O	E	5
23	IX.	E	6	23	IX.	A	6		23	XVII.	F	4
24	O	F	5	24	O	B	5		24	VI.	G	3
25	XVII.	G	4	25	XVII.	C	4		25	O	A	2
26	VI.	A	3	26	VI.	D	3		26	XIV.	B	1
27	O	B	2	27	O	E	2		27	III.	C	*
28	XIV.	C	1	28	XIV.	F	1		28	O	D	29
				29	III.	G	*		29	XI.	E	28
				30	O	A.	29		30	O	F	27.

Fig. 7

July.				September.				November.			
Days of Month	Golden Numbers	Dominical Letters	Epact	Days of Month.	Golden Numbers	Dominical Letters	Epact.	Days of Month.	Golden Numbers	Dominical Letters	Epact.
1	XIX	G	26	1	XVI	F	23	1	O	D	21
2	VIII	A	25.XXV.	2	V.	G	22	2	XIII.	E	20
3	O	B	24	3	O	A	21	3	II.	F	19.
4	XVI.	C	23	4	XIII.	B	20	4	O	G	18
5	V.	D	22	5	II.	C	19	5	X.	A	17
6	O	E	21	6	O	D	18	6	O	B	16
7	XIII.	F	20	7	X	E	17	7	XVIII.	C	15
8	II.	G	19	8	O	F	16	8	VII.	D	14
9	O	A	18	9	XVIII.	G	15	9	O	E	13
10	X.	B	17	10	VII.	A	14	10	XV.	F	12
11	O	C	16	11	O	B	13	11	IV.	G	11
12	XVIII.	D	15	12	XV	C	12	12	O	A	10
13	VII.	E	14	13	IV	D	11	13	XII.	B	9
14	O	F	13	14	O	E	10	14	I.	C	8
15	XV.	G	12	15	XII.	F	9	15	O	D	7
16	IV.	A	11	16	I	G	8	16	IX.	E	6
17	O	B	10	17	O	A	7	17	O	F	5
18	XII.	C	9	18	IX.	B	6	18	XVII.	G	4
19	I.	D	8	19	O	C	5	19	VI.	A	3
20	O	E	7	20	XVII.	D	4	20	O	B	2
21	IX.	F	6	21	VI.	E	3	21	XIV.	C	1
22	O	G	5	22	O	F	2	22	III.	D	*
23	XVII.	A	4	23	XIV	G	1	23	O	E	29
24	VI.	B	3	24	III.	A	*	24	XI.	F	28
25	O	C	2	25	O	B	29	25	XIX.	G	27
26	XIV.	D	1	26	XI.	C	28	26	O	A	26.XXV.
27	III.	E	*	27	XIX.	D	27	27	VIII.	B	25.24
28	O	F	29	28	O	E	26.XXV.	28	O.	C	23.
29	XI.	G	28	29	VIII.	F	25.24	29	XVI.	D	22
30	XIX.	A	27	30	O	G	23	30	V.	E	21.
31	O	B	26.XXV.								

August.				October.				December.			
1	VIII	C	25.24	1	XVI	A	22	1	XIII.	F	20
2	XVI.	D	23	2	V	B	21	2	II.	G	19
3	V.	E	22	3	XIII.	C	20	3	O	A	18
4	O.	F	21	4	II.	D	19	4	X.	B	17
5	XIII.	G	20	5	O	E	18	5	O	C	16
6	II.	A	19	6	X	F	17	6	XVIII.	D	15
7	O.	B	18	7	O	G	16	7	VII.	E	14
8	X	C	17	8	XVIII.	A	15	8	O	F	13
9	O.	D	16	9	VII	B	14	9	XV.	G	12
10	XVIII.	E	15	10	O	C	13	10	IV	A	11
11	VII.	F	14	11	XV	D	12	11	O	B	10
12	O	G	13	12	IV.	E	11	12	XII.	C	9
13	XV.	A	12	13	O	F	10	13	I.	D	8
14	IV	B	11	14	XII	G	9	14	O	E	7
15	O.	C	10	15	I.	A	8	15	IX.	F	6
16	XII.	D	9	16	O	B	7	16	O	G	5
17	I.	E	8	17	IX	C	6	17	XVII.	A	4
18	O.	F	7	18	O	D	5	18	VI.	B	3
19	IX.	G	6	19	XVII.	E	4	19	O	C	2
20	O	A	5	20	VI	F	3	20	XIV	D	1
21	XVII	B	4	21	O	G	2	21	III.	E	*
22	VI.	C	3	22	XIV.	A	1	22	O	F	29
23	O	D	2	23	III.	B	*	23	XI.	G	28
24	XIV	E	1	24	O	C	29	24	XIX	A	27
25	III	F	*	25	XI.	D	28	25	O	B	26
26	O	G	29	26	XIX	E	27	26	VIII	C	25.XXV.
27	XI	A	28	27	O	F	26	27	O	D	24
28	XIX	B	27	28	VIII	G	25.XXV.	28	XVI	E	23
29	O	C	26	29	O	A	24	29	V.	F	22
30	VIII.	D	25.XXV.	30	XVI	B	23	30	O	G	21
31	O	E	24	31	V.	C	22	31	XIII.	A	20.XIX.

Fig. 8

the Middle Ages it was taken for granted that these were the only days on which a new moon could occur.

In order to ascertain the date of Easter for any particular year, it was only necessary to find the Golden Number of the year in question (*i.e.* its position in the lunar cycle). This gave the dates of all the new moons of that year, from which it was a simple matter to find the first fourteenth day of the moon occurring on or after 21st March. Having ascertained that date the next step was by reference to a table to ascertain the dominical letter for the year in question. That known, it was easy to find the first Sunday after that date. The day thus ascertained was Easter Sunday. The movable feasts were deducible therefrom in accordance with the ecclesiastical rule.

We have seen that 235 lunations fell short of 19 Julian years by 1 hour 29 minutes. That difference amounts to a day in about 308 years, at the expiry of which time the new moons would fall one day earlier than was noted in the Lunar Almanac. It would have been an extremely simple matter once in 308 years to prepare and publish a new table of Golden Numbers giving effect to this simple correction. But that was not done. The dread of innovation or some sort of superstitious regard for the established table apparently prevented any change, and the original scheme of Golden Numbers continued in use up to the date of the Gregorian reform, although by that time the new moons actually occurred about four days earlier than the dates indicated in the table.

The table of Golden Numbers could easily have been adjusted to the new Calendar. The omission of ten days in the year 1582 required that the dates of the new moons should be shifted to dates ten days later. But owing to the accumulated error already referred to they ought to have been moved to dates four days earlier. By shifting them six days later they would have been in their correct places in the Gregorian Calendar. This, however, was not done—at least not officially. The use of the Golden Numbers was officially abandoned, and a slightly different expedient was adopted by Clavius, the priest employed by Gregory XIII to prepare the necessary tables for operating the reformed Calendar.

Clavius made use of the Epact—a name given to the figure which represents the age of the moon on 1st January. Instead of writing opposite the date of each new moon the number of the year in the lunar cycle—*i.e.* its Golden Number—he entered on these dates the figure representing the Epact for that year. So far as regards the ascertainment of the date of Easter in any given year, there was not much to choose between the two methods. Both made use of the cycle of 19 years. It mattered little which figure was employed to identify the dates of the new moons in the Lunar Almanac.

As in the former case you ascertained by calculation or by reference to a table the Golden Number of the year in question, so in the latter case you ascertained from a table or otherwise the Epact of the year and you then consulted the Lunar Almanac and found there opposite the appropriate Epact the new moon from which the date of the first full moon after 21st March was deduced.

The Epact had this advantage, that it told the age of the moon on 1st January from which, by a simple calculation to be afterwards explained, it was possible to ascertain the dates of all the new and full moons throughout the year.

The principal advantage of the Epact, however, in the eyes of Clavius doubtless was that it was possible to construct a whole series of 30 Epact cycles[1]—each diminishing by unity from its predecessor—such that by shifting from one cycle to the next at certain centurial years the Epact would be kept perpetually in an approximately true relation to the dates of the astronomical new moons. This complete or extended table of Epacts contains the Epacts for a period of 7000 years, at the termination of which time if the Gregorian Calendar is still valid without alteration, the whole series of cycles repeats itself. This complete table of Epacts is appended, and we must now proceed to show in detail how the cycle of Epacts is constructed.

Starting with a year in which the new moon fell on 1st January, as the length of 12 lunations is 354 days it follows that the age of the moon on 1st January of the following year will be 11 days. The Epact for that year will therefore be 11. Similarly

[1] These had been constructed by Aloysius Lilius.

Complete . Table . of . Epact . Cycles.

Centuries	Index	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
		THE					GOLDEN						NUMBERS							
1700 1800 8700	C.	*	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15	26	7	18
1900 2000 2100	B.	29	10	21	2	13	24	5	16	27	8	19	*	11	22	3	14	XXV	6	17
2200 2400	A.	28	9	20	1	12	23	4	15	26	7	18	29	10	21	2	13	24	5	16
2300 2500	u.	27	8	19	*	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15
2600 2700 2800.	t.	26	7	18	29	10	21	2	13	24	5	16	27	8	19	*	11	22	3	14
2900 3000	s.	25	6	17	28	9	20	1	12	23	4	15	26	7	18	29	10	21	2	13
3100 3200 3300	r.	24	5	16	27	8	19	*	11	22	3	14	XXV	6	17	28	9	20	1	12
3400 3600	q.	23	4	15	26	7	18	29	10	21	2	13	24	5	16	27	8	19	*	11
3500 3700	p.	22	3	14	25	6	17	28	9	20	1	12	23	4	15	26	7	18	29	10
3800 3900 4000	n.	21	2	13	24	5	16	27	8	19	*	11	22	3	14	XXV	6	17	28	9
4100	m.	20	1	12	23	4	15	26	7	18	29	10	21	2	13	24	5	16	27	8
4200 4300 4400	l.	19	*	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15	26	7
4500 4600	k.	18	29	10	21	2	13	24	5	16	27	8	19	*	11	22	3	14	XXV	6
4700 4800 4900	i.	17	28	9	20	1	12	23	4	15	26	7	18	29	10	21	2	13	24	5
5000 5200	h.	16	27	8	19	*	11	22	3	14	25	6	17	28	9	20	1	12	23	4
5100 5300	g	15	26	7	18	29	10	21	2	13	24	5	16	27	8	19	*	11	22	3
5400 5500 5600	f	14	25	6	17	28	9	20	1	12	23	4	15	26	7	18	29	10	21	2
5700 5800	e	13	24	5	16	27	8	19	*	11	22	3	14	XXV	6	17	28	9	20	1
5900 6000 6100	d.	12	23	4	15	26	7	18	29	10	21	2	13	24	5	16	27	8	19	*
6200 6400	c	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15	26	7	18	29
6300 6500	b.	10	21	2	13	24	5	16	27	8	19	*	11	22	3	14	XXV	6	17	28
6600 6800	a.	9	20	1	12	23	4	15	26	7	18	29	10	21	2	13	24	5	16	27
6700 6900	P	8	19	*	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15	26
7000 7100 7200	N	7	18	29	10	21	2	13	24	5	16	27	8	19	*	11	22	3	14	XXV
7300 7400	M	6	17	28	9	20	1	12	23	4	15	26	7	18	29	10	21	2	13	24
7500 7600 7700	H	5	16	27	8	19	*	11	22	3	14	25	6	17	28	9	20	1	12	23
7800 8000	G	4	15	26	7	18	29	10	21	2	13	24	5	16	27	8	19	*	11	22
7900 8100	F	3	14	25	6	17	28	9	20	1	12	23	4	15	26	7	18	29	10	21
8200 8300 8400	E	2	13	24	5	16	27	8	19	*	11	22	3	14	XXV	6	17	28	9	20
1500 1600 8500	D	1	12	23	4	15	26	7	18	29	10	21	2	13	24	5	16	27	8	19

Fig. 9

at the end of the next year the Epact will be 22. In the third year it will be 33, but that of course means that another lunation would have been completed and that there were 13 new moons in the third year. The age of the moon on the 1st January following would therefore be $33 - 30 = 3$. Thus the rule for constructing a cycle of Epacts is quite simple, *viz.* to add 11 to the Epact of the year preceding and deduct 30 when the sum exceeds that figure. Thus the Epacts for the cycle in question are: 11, 22, 3, 14, 25, 6, 17, 28, 9, 20, 1, 12, 23, 4, 15, 26, 7, 18, 29.

If the same rule were continued in the year which follows the last of this cycle (*i.e.* the first year of the next cycle) the following Epact would be $29 + 11 = 40 - 30 = 10$. The cycle would not therefore be repeated. But it would not be correct so to continue the series according to rule, for this reason: The numbers 11 and 30 which are added and subtracted as above described are approximations only. The exact Epact or the difference between the length of the Julian year and the length of twelve lunations is not 11 days but 10 days 21 hours 11 minutes and the exact length of the lunation is not 30 days but 29 days 12 hours 44 minutes. To show the effect of using the exact figures we give in parallel columns a table in which these are used (seconds excepted) and a table in which the conventional figures 11 and 30 are employed.

Now in this table the Epact (11) is added 19 times and the lunation (30) is deducted 6 times. The difference between 11 and the exact Epact of 10 days 21 hours 11 minutes is 2 hours 49 minutes, which is the amount in excess of the true figures which has been added 19 times—that is to say, the addition is excessive by 53 hours 31 minutes. Again 30 has been deducted 6 times in place of 29 days 12 hours 44 minutes; therefore 11 hours 16 minutes too much has been subtracted 6 times; that is to say, 67 hours 36 minutes too much is subtracted, from which deducting 53 hours 31 minutes over-added, leaves 14 hours 5 minutes, which exactly corresponds with the table.

But 29 days 14 hours 5 minutes is more than a lunation. From this deduct therefore the length of a lunation, 29 days 12 hours 44 minutes, leaving 1 hour 21 minutes, to which adding 8 minutes for seconds omitted gives 1 hour 29 minutes as the

Years	True times			Conventional times
	d.	h.	m.	d.
1	10	21	11	11
	10	21	11	11
2	21	18	22	22
	10	21	11	11
	32	15	33	33
	29	12	44	30
3	3	2	49	3
	10	21	11	11
4	14	0	0	14
	10	21	11	11
5	24	21	11	25
	10	21	11	11
	35	18	22	36
	29	12	44	30
6	6	5	38	6
	10	21	11	11
7	17	2	49	17
	10	21	11	11
8	28	0	0	28
	10	21	11	11
	38	21	11	39
	29	12	44	30
9	9	8	27	9
	10	21	11	11
10	20	5	38	20
	10	21	11	11
	31	2	49	31
	29	12	44	30
11	1	14	5	1
	10	21	11	11
12	12	11	16	12
	10	21	11	11
13	23	8	27	23
	10	21	11	11
	34	5	38	34
	29	12	44	30
14	4	16	54	4
	10	21	11	11
15	15	14	5	15
	10	21	11	11
16	26	11	16	26
	10	21	11	11
	37	8	27	37
	29	12	44	30
17	7	19	43	7
	10	21	11	11
18	18	16	54	18
	10	21	11	11
19	29	14	5	29

error at the end of the cycle, which exactly corresponds to the error as derived from the total number of days in the cycle.

It follows, therefore, that instead of counting from the last Epact of 29 it is more correct to count from it as 30 and start the new cycle from zero, and thus carry forward, to the next cycle, only the true residual error of 1 hour 29 minutes. Such was the principle upon which the pre-Gregorian Epact cycle was constructed.

The Epact was known before the Gregorian reform, although not used officially. The cycle given above commencing with Epact 11 was supposed to have commenced in the year 1 B.C.

There was still, however, the residual error of 1 hour 29 minutes in each lunar cycle, and, therefore, in the course of 308 years the Epacts if originally correct would all be one day wrong. To correct the effect of this accumulating error in the cycle of Epacts all that is necessary is to increase each Epact by one at the end of 308 years or thereby. This was not attended to in pre-Gregorian times, but it is what Clavius decided to do. In point of fact for the sake of simplicity he proposed to increase the cycle by unity at certain centurial years only and to make the change eight times in 2500 years—seven times at the end of 300 years and the eighth time at the end of 400 years. The average interval between a shift of Epacts was thus a little over 312 years which he considered a sufficiently close approximation. The readjustment of the Epacts by increasing them by unity on these dates has, by some writers, been called the lunar correction.

But there was another correction necessary in order to keep the Epacts in harmony with the new Calendar.

In the Metonic cycle the length of the year was taken to be 365 days 6 hours exactly. That is the assumed length under the Julian Calendar, hence we have called it the Julian year. Now this length as we know was 11 minutes 14 seconds in excess of the true tropical year, to correct which Pope Gregory XIII decided to delete the intercalary or leap day in three out of every four centurial years. It follows that when the cycle of Epacts arrived at a centurial year, which was a common year under the Gregorian Calendar, the order of the cycle would be

dislocated and the new moons would not arrive until one day later in the Calendar than the day on which they would have arrived if the Julian Calendar had remained unreformed. To correct this dislocation it was necessary that when the cycle of Epacts reached such a centurial year the Epact should thereafter be reduced by unity. This then is what Clavius resolved, and this correction has received the name of the solar correction.

It will be observed that the solar correction is made in the reverse order to the lunar. The latter requires the Epacts to be increased by one, the former requires them to be diminished by one. When, therefore, as will frequently happen, we arrive at a centurial year in which both corrections are required, it follows that at that time no change is necessary, and the cycle of Epacts is continued without alteration. Clavius started with a cycle which he assumed to be operative at the beginning of the current century, *i.e.* 1500 A.D. He therefore required a lunar correction in 1800 A.D. and thereafter he proposed to make them at seven intervals of 300 years and one of 400. The dates when the solar correction fell due were fixed by the Gregorian Calendar. In the annexed table we show for the period up to 6000 A.D. the years in which each of the two corrections are respectively required, and when they cancel each other.

It will be seen that in 4000 years from 1900 there are 13 lunar corrections required of which 10 are cancelled leaving 3 operative. On the other hand, in the same period, there are 30 solar corrections of which of course 10 are cancelled, leaving 20 operative, the result being that the successive cycles of Epacts are subject to a slow nett retrogradation, each cycle being diminished by unity as compared with its predecessor—until the series of possible Epacts is exhausted, the limit being determined by the fact that no Epact can exceed 30, the assumed full length of the lunation. Of course in the rare occasions when the lunar correction stands uncancelled the line of Epacts is moved in the reverse direction.

The complete table of Epacts already referred to exhibits all possible Epact cycles, and it will be observed that these are exhausted in a period of 7000 years, the cycle which applies to 8500 A.D. being the same cycle as that which applies to 1500 A.D.

Years in which occurs the solar correction	Uncancelled	Years in which occurs the lunar correction	Uncancelled
1700	1700	—	—
1800	—	1800	—
1900	1900	—	—
2100	—	2100	—
2200	2200	—	—
2300	2300	—	—
—	—	2400	2400
2500	2500	—	—
2600	2600	—	—
2700	—	2700	—
2900	2900	—	—
3000	—	3000	—
3100	3100	—	—
3300	—	3300	—
3400	3400	—	—
3500	3500	—	—
—	—	3600	3600
3700	3700	—	—
3800	3800	—	—
3900	—	3900	—
4100	4100	—	—
4200	4200	—	—
4300	—	4300	—
4500	4500	—	—
4600	—	4600	—
4700	4700	—	—
4900	—	4900	—
5000	5000	—	—
5100	5100	—	—
—	—	5200	5200
5300	5300	—	—
5400	5400	—	—
5500	—	5500	—
5700	5700	—	—
5800	—	5800	—
5900	5900	—	—

Such is the complete scheme of Gregorian Epacts laboriously constructed by Lilius and reproduced by Clavius, but still far from astronomically perfect. It has apparently served its purpose, and was at any rate involved by its author in such a cloud of erudite detail that few have ventured to master its really simple rules, and few, therefore, have dared to criticise it. Clavius, like the cuttle-fish, protected his scheme by the ocean of ink with which he surrounded it.

When, however, the full series come to be written down in their places in the Perpetual Lunar Almanac there are one or two adjustments prescribed by Clavius in order to obviate the most apparent defects of his scheme. These are:

(1) The Epacts are entered in the almanac from 1st January onwards in the reverse order, beginning with 30, which is the age of the moon when a new moon occurs just after the year opens. If this were continued without a break the series would occupy 360 days in place of 354—the true length of 12 lunations. Accordingly at every second lunation the Epacts 24 and 25 are written opposite the same date. These occur in the months of February, April, June, August (1st), September (29th) and November. The reason is obvious; but an equally obvious consequence is that, in a lunar cycle which contains both Epact 24 and Epact 25, a new moon would be made to fall on the same day twice within a single cycle of 19 years. This as a physical fact does not happen. To prevent an error so glaring an alternative date (at Epact 26) is assigned to Epact 25, which is entered on that other date in a distinctive character of type. This is intended to intimate that the date on which it is so placed is to be taken and employed as the correct date when such a step is rendered necessary to avoid the dating of two new moons on the same day within one lunar cycle. An examination of the complete table of Epacts reveals the fact that in no one of the series do the three Epacts 24, 25 and 26 all occur. Consequently Epact 25 is quite sure to find a safe place in one or other of the two days to which it is allotted.

An examination of the table further shows that in every series on which both 24 and 25 occur (that is in the series denoted by the index letters *b*, *e*, *k*, *n*, *r*, *B*, *E*, *N*) the 25 is found

in a year later than the eleventh year of the cycle. In these years, therefore, the Epact 25 must be held to fall on the day on which it stands alongside of 26, whilst if it falls on any of the first eleven years of the cycle (as it did in the cycle of Epacts ending at 1899) it should be taken as dated of the day on which it stands alongside of 24.

It will be noted that this collision between the Epacts 24, 25, 26 only occurs every second month, *i.e.* in those months in which two Epacts are entered on one day. In the other six months the Epact 25 falls on the proper day irrespective of whether or no it be shunted in the six months in which the collision occurs. This is the reason why in January, March, May, July, August (30th), October and December both figures for the Epact 25 are entered on one day.

The reason why Clavius fixed on 24, 25, 26 for the purpose of this adjustment is said to have been because in their case the 24–25 conjunction never clashed with the 25–26 conjunction. He may have also been influenced by the fact that they fell about 14 days after the vernal equinox.

(2) It may also be noted that on 31st December the Epact XIX is placed along with 20, being also recorded in a distinctive character.

The reason is that when the Epact is XIX, in other words if 19 is the age of the moon on 1st January, it will be found by calculation that a new moon is due on 31st December. If the year with Epact 19 happens to be the last year of a cycle (a thing which only occurs with one line of Epacts, namely that indicated by the letter *D*) it would be very awkward not to record the new moon due on that day—otherwise the record in the almanac would be conspicuously inconsistent with the reading of the Epact for the next year in which the same cycle recommences with Epact 1.

That is the real reason for the entry of Epact XIX along with Epact 20 on 31st December. The reason usually given is that the last intercalary month of the Metonic cycle had only 29 days, which is true and was so settled for the same reason, namely, to prevent an obvious misplacement of a new moon at the close of a cycle.

The cycle *D*, however, ceased to operate with the year 1699 and will not be again in use until the year 8500, so that we need not worry over this dilemma.

Notwithstanding these adjustments the elaborate tables of Clavius are by no means perfect. They deviate more or less by a day or two from the astronomical Ephemeris, and they are not even completely successful from the ecclesiastical standpoint. In the earlier days of the Church a great desire existed to ensure that the Easter date should always happen after and should never coincide with the date of the Jewish Passover. Clavius specially intimated his intention to secure this result. Even in that however he was not always successful, for in the years 1805 and 1825 Easter Sunday under his tables fell on the very same day as that on which the Passover was observed.

When the Gregorian Calendar was introduced in 1582, 10 days were omitted from that year but no alteration was made in the constant succession of years in the lunar cycle of 19 years, hence the reform involved no change in the order of the Golden Numbers.

A lunar cycle was assumed to have commenced in the year before 1 A.D., called by astronomers the year 0 A.D., and by chronologers the year 1 B.C., and the Golden Numbers have run on continuously since then in successive cycles of 19, so that to find the Golden Number of any year it is only necessary to add 1 to its date in the Gregorian Calendar and divide by 19. This eliminates the complete cycles which have elapsed since 1 B.C. and the remainder gives the Golden Number of the year in question. If there is no remainder it is the last year of a cycle and the Golden Number is 19.

Dates for the new and hence for the full moons were assigned to each of the 19 years of the cycle and these were repeated for centuries, cycle after cycle, with the result already indicated that in the course of time they had moved away several days from the astronomical date. In the sixteenth century the astronomical moons happened about four days earlier than their assumed date in the lunar cycle. We have already shown how, at the time of the reform, if the new moons had been moved six days

later they would have regained an approximately true position in the Calendar.

This in effect is what Clavius did only (1) in order to avoid collision with the Passover he assumed the error of four days which had grown up to be only three; and (2) in place of the Golden Number he inserted the Epact.

The cycle of Epacts applicable before the reform was that indicated by line *C*. The line of Epacts brought into operation after the reform was that indicated by *D*.

The Golden Number of the year 1582 being 6 its Epact was 26. This line continued in force until 1700, when line *C* became operative, and so remained until 1900, when a transfer took place to line *B*. The year 1900 being the first of a lunar cycle its Golden Number was 1, its Epact was 29.

In reference to the Epacts line *D* a rather misleading statement is made by Professor De Morgan in the *Book of Almanacs* (p. xiv):

The year 1577 was the first of a lunar cycle. A cycle of line *D* therefore started with that year. These Epacts are 1, 12, 23, 4, 15, 26, 7, 18, 29, 10, 21, 2, 13, 24, 5, 16, 27, 8, 19. But this series was not really put into operation until 1582, which being the sixth year of the cycle had for its Epact 26.

De Morgan prints the cycle commencing with this number and ending with 15. He says "from 1582 to 1699, 19 is used as 20 and the cycle of Epacts is 26, 7, 18," etc.

This reads as if an unexplained saltus took place in the middle of the cycle whereas in fact 19 was the Epact of the last year of the cycle, and the saltus is the usual and recognised saltus already explained as made at the end of each cycle to enable the cycle to be again repeated.

Again 1699 was the ninth year of a lunar cycle with Epact 29. According to rule the cycle was not completed, but a shift was made to line *C* in 1700 and of that year the Epact was 9, being the Epact of the tenth year of that cycle.

De Morgan tells us that for the passage from 1699 to 1700 only 10 is added, and from thence to 1899, 18 is used as 19 and the cycle of Epacts is 9, 20, 1, 12, 23, 4, 15, 26, 7, 18, 30, 11, 22, 3, 14, 25, 6, 17, 28. The explanation is of course that in

passing from 1699 to 1700 a shift is made to a new line of Epacts diminished by unity, and that 18 is "used as" 19 for exactly the same reason as already indicated, *viz*. to comply with the rule which was applied to the last year of each cycle.

De Morgan then gives the cycle *B* correctly, but without finding room for the explanation already given (*ante*, pp. 76, 77) for 25 being treated as 26 in the course of this particular cycle.

We have already explained that since 325 A.D. the accepted date of Easter Sunday has been the Sunday after the first 14th day of the moon falling on or after the vernal equinox. As it was the Sunday after that moon it could not fall on 21st March. The earliest possible date for Easter was therefore the 22nd March. If a full moon fell on 20th March the next 14th moon would not occur until 18th April. These dates are known as the Paschal Term. The latest possible date for Easter Sunday would be seven days after 18th April, *viz*. 25th April. Thus the festival oscillates with an amplitude of 35 days.

Various ingenious tables have been prepared for enabling Easter to be ascertained over a longer or shorter period. Probably the best of these is that printed in the Church of England Prayer Book—said to have been constructed by Rev. Dr Bradley, the Astronomer Royal in 1752, when the Gregorian reform was legalised in England. The whole of the thirty different lines of Epact cycles which compose the Calendar Table of Epacts are covered by this table which is valid for the whole period of 7000 years. But these different lines are not identified by letters of the alphabet as in the Table of Epacts, but are numbered successively from 0 to 29. At the left of Bradley's table is a column containing the possible dates of the Paschal Full Moon from 21st March to 18th April. In the next column are recorded the week-day letters applicable to each of these dates. To the right are placed 19 columns numbered successively—one being appropriated to each year of a lunar cycle. These 19 columns are filled as follows:

Starting with 1582, when the cycle of Epacts numbered 0 came into operation, the figure 0 is placed opposite the Paschal Moon of that year. The full moon of each following year would of course always fall 11 days earlier. In this way the dates of the

Paschal Full Moon		Sunday Letters	The Golden Numbers. 1.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Index to Epacts
March	21.	C.	8	19	0	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15	26	P
March	22.	D.	9	20	1	12	23	4	15	26	7	18	29	10	21	2	13	24	5	16	27	c
March	23.	E.	10	21	2	13	24	5	16	27	8	19	0	11	22	3	14	25	6	17	28	b
March	24.	F.	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15	26	7	18	29	c
March	25	G.	12	23	4	15	26	7	18	29.	10	21	2	13	24	5	16	27	8	19	0	d
March	26	A.	13	24	5	16	27.	8	19	0	11	22	3	14	25	6	17	28	9	20	1	e
March	27	B.	14	25	6	17	28	9	20	1	12	23	4	15	26	7	18	29	10	21	2	f
March	28	C.	15	26	7	18	29.	10	21	2	13	24	5	16	27	8	19	0	11	22	3	g
March	29	D.	16	27	8	19	0	11	22	3	14	25	6	17	28	9	20	1	12	23	4	h
March	30	E.	17	28	9	20	1	12	23.	4	15	26	7	18	29	10	21	2	13	24	5	i
March	31.	F	18	29	10	21	2	13	24	5	16	27	8	19	0	11	22	3	14	25	6	k
April	1.	G	19	0	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15	26	7	l
April	2.	A	20	1	12	23	4	15	26	7	18	29	10	21	2	13	24	5	16	27	8	m
April	3.	B	21	2	13	24	5	16	27.	8	19	0	11	22	3	14	25	6	17	28	9	n
April.	4.	C	22	3	14	25	6	17	28.	9	20	1	12.	23	4	15	26	7	18	29	10	p
April.	5.	D	23	4	15	26	7	18	29.	10	21	2	13	24	5	16	27	8	19	0	11	q
April.	6	E	24	5	16	27	8	19	0	11	22	3	14	25	6	17	28	9	20	1	12	r
April.	7.	F	25	6	17.	28	9.	20	1.	12	23.	4	15	26	7	18	29	10	21	2	13	s
April.	8.	G	26	7	18	29.	10	21	2	13	24	5	16	27.	8	19	0	11	22	3	14	t
April.	9	A	27	8	19	0	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15	u
April.	10	B	28	9	20	1	12	23	4	15	26	7	18	29.	10	21	2	13	24	5	16	A
April	11.	C	29	10	21	2	13.	24	5	16	27	8	19	0	11	22	3	14	25	6	17	B
April.	12	D	0	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15	26	7	18	C
April.	13.	E	1	12	23	4	15	26	7	18	29.	10	21	2	13	24	5	16	27	8	19	D
April.	14	F	2	13	24	5	16	27	8	19	0	11.	22	3	14	25	6	17	28	9	20	E
April.	15	G	3	14	25	6	17.	28	9	20	1	12	23	4	15	26	7	18	29	10	21	F
April.	16	A	4	15	26	7	18	29.	10	21	2	13	24	5	16	27	8	19	0	11	22	G
April.	17	B	5	16	27.	8	19	0	11	22	3	14	25	6	17	28	9	20	1	12	23	H
April	17	B												7	18	29	10	21	2	13	24	
April.	18	C	6	17	28	9	20	1	12	23	4	15	26									M
April	18	C	7	18	29	10	21	2	13	24	5	16	27	8	19.	0	11	22.	3	14	25.	N

Fig. 10

first cycle of Epacts are filled in. The next cycle, which in this table is numbered 1, would fall one day later, and so on with each successive cycle. In this very simple way a reliable table of the Paschal Full Moons for 7000 years is completed. Having ascertained the date of the full moon all that is necessary is to refer to the year letter and find by the Table of Dominical Letters, which in the Prayer Book is printed alongside of the table under description, on what day of the week the Paschal Moon occurred and what therefore was the date of the next Sunday.

Many other tables have been devised with more or less ingenuity, but it seems unnecessary to describe them. If the reader has succeeded in following our explanations of the simple principles on which they must all be based he should have no difficulty either in using or understanding them.

We may in conclusion point out that in a Perpetual Lunar Calendar a given Epact may occur much more frequently on certain days than another does on other days. Thus for the year in which the almanac gives a Sunday on 22nd March, there can only be one Epact, for those in which Sunday falls on 23rd March two and so on up to seven.

One convenient use of the Epact may be noted, *viz*. to find the age of the moon on any given date of any month of any year of which the Epact is known. Take the Epact, add to it the number of the month counting from March and the day of the month. If the sum be less than 30 it equals the moon's age, if more than 30 divide by 30 and the remainder is the moon's age. This rule only applies to the 12 months counting from 1st March.

PART IV

XVI

THE USES OF THE CALENDAR

THE CALENDAR is required for two main purposes:

I, and primarily: *to fix dates*; that is, to supply a continuous register of days, months and years on which we can record in their proper place and order the dates of past and future events and engagements.

II. To furnish an instrument whereby we may *measure* out equal *intervals of time*.

(I) The dates to be recorded are either:

1. Physical or natural events or phenomena.
2. Civil events or appointments.
3. Ecclesiastical events or appointments.

In each of these cases we should distinguish between past and future events.

1. Physical events. These include the Ephemerides: the regular astronomical *periodic phenomena*, the equinoxes, solstices, eclipses, transits, appearances of comets, etc.; and terrestrial phenomena: tides, seasonal changes, harvests and so forth. It will be noted that, as regards the *past*, in addition to the regular ephemerides we also require to record exceptional cataclysmic non-periodic events both celestial and terrestrial (including such as earthquakes, storms, volcanic eruptions, tidal waves and the like). As regards the *future*, the record of periodic events is still more important—indeed the recording of these by anticipation is one of the main objects of a Calendar. Irregular, exceptional, non-periodic events cannot of course be predicted and the Calendar of the *future* cannot contain any such.

A class of almanac has been continuously published for many years professing to foretell the occurrence of future non-periodic events, both physical and civil, but these if they are now seriously

intended have no scientific value and need not be further referred to.

2. Civil or historical events. (*a*) As regards such events occurring in the course of human history the record of *past* events of this class is one of the principal uses of a Calendar. A proper record of dates is the true framework of civil history, without which no clear and adequate knowledge of human history is possible. To record these events at their proper dates is the object of chronology.

(*b*) As regards the *future* what we require to record are chiefly cyclical or periodic events and appointments. The terms of the possession of houses and lands, the terms of payment of rents and interests, salaries and wages, the recurring dates of markets, fairs, sessions of law courts, of Parliament and of local authorities, the terms of schools and universities, the dates when names must be enrolled, returns lodged, claims intimated, the close times for game, public holidays and festivals, birthdays and commemorative anniversaries, etc. With few exceptions these *future* civil events are recurrent and periodic.

3. A third class of dates is composed of the dates of the ecclesiastical Calendar. These also may be divided into *past* and *future recurring* events, on a principle similar to that applicable to civil dates. The ascertainment of the date of Easter—the principal *future* date of the ecclesiastical Calendar—has dominated the whole history of Calendar construction, and involves a curious composition of *physical* and *civil* cycles.

(II) The Calendar as a measure of intervals of time. The second and hardly less important use and purpose of the Calendar is to provide a means of measuring intervals of time.

Contracts of hiring, whether of lands, houses, shops or of the loan of money, or of labour or services, are usually made for a fixed interval of time and the remuneration is estimated by reference thereto. A uniform or standard interval is required for these purposes. Accounts of monetary transactions are, or should be, closed and balanced at fixed intervals, and these if possible should have a simple and definite correspondence with the periodic times of payment. Recurring intervals of uniform or standard length are desiderated also for the efficient use and

comparison of statistics, the preparation of financial estimates and other similar purposes. It is frequently desirable that the terms of these intervals should correspond with the particular dates appropriated to money payments or with some other special fixture. It is consequently desirable and almost imperative that the necessary intervals should be furnished by and ascertainable from the Calendar.

To anyone who considers the foregoing imperfect summary of the uses for which a Calendar is required, it should be evident that its proper adjustment is of national importance, however little attention it receives at the hands of the general public or of the cranks and faddists who too often control the business of Parliament.

XVII

THE DEFECTS OF THE CALENDAR

Having thus indicated the purposes for which a Calendar is used, we must now enquire how far they are efficiently served by the existing Calendar.

I. 1. As regards the recording of physical events both past and future what is required is a Calendar which maintains a close approximation to its astronomical basis, and which is repeated in a stable, uniform, simple and regular order. The present Calendar amply fulfils these requirements. Its only irregularity is the intercalation of a day every fourth year. This has a certain disturbing effect and produces a certain oscillation in the date of the vernal equinox. But it is the minimum possible of intercalation and its occurrence is so regular that the consequent inconvenience is small. Even that can be lessened in some cases by computing the annual interval from 1st March. On the whole it may be safely affirmed that the present Calendar adequately fulfils these calendrial purposes, and that for them no better arrangement could be imagined.

2 (*a*). As regards civil events *bypast* the same remarks apply. It is true that chronology has had much trouble with the determination of dates, but that trouble has been due to the irregularities and inconsistencies of other Calendars used in earlier

times—not to the Gregorian. The only part of the trouble for which it can be held responsible is the confusion which has arisen between the use of the old and new style—a confusion due exclusively to the unfortunate circumstance that the Gregorian Calendar at its introduction was made to take effect retrospectively as if it had started with the year 325 A.D. Had it been introduced to operate for the future only and commencing with the date of its introduction no such confusion would have arisen.

The different dates of commencement of the year and the different dates at which the Gregorian Calendar was adopted by different countries have also been responsible for certain complications, but these are not in any way attributable to the construction of the Gregorian Calendar itself. With the additional assistance derivable from Scaliger's comprehensive device of the Julian Period no more convenient system of date recording can be imagined; and any change calculated to disturb the continuity of our dating system is to be deprecated.

2 (*b*). *Future* civil events and appointments. In the case of certain dates of this class the existing Calendar is satisfactory. This applies to dates which, like the Ephemerides, are recorded without variation on the true day of real or assumed occurrence. Such dates have been called dates-absolute, or, to borrow a term from the Roman Calendar, dates-stative. They include most commemorative anniversaries, birthdays, death days, dates of great actions, discoveries, reforms or other political or historical occurrences, also such fixtures as the close times of game which are directly based on an assumed seasonal necessity.

The great majority of future civil dates however involve a double reference—*i.e.* both to the Calendar date and the occurrence of the week day. In these cases the constant fluctuation in the relation between month day and week day seriously disturbs the operation of our present dating system.

Such dates may be divided into two classes:

Class A, including (1) legal terms, dates of sitting and rising of law courts, schools, universities.

(2) Statutory dates for meetings of magistrates, town and county councils and other local authorities, dates for making statutory returns and lodging claims.

(3) Quarterly term days, money payment and removal terms, maturities of bills.

(4) Certain civil fête days, national holidays and anniversary celebrations.

Class B, including (1) the movable feasts of the Church, Easter and its consequents.

(2) Meetings of magistrates, local authorities, etc., *when fixed for particular week days.*

(3) Local markets and fairs.

(4) Local festivals, holidays and celebrations.

These all depend upon a joint adjustment of month day and week day. In the case of Class *A* the events are fixed for a particular Calendar date or for the first lawful day next ensuing or next preceding. The month day alone does not determine the observance. It is the primary co-ordinate, but the observance must also avoid a Sunday or other legal blank day. When the Calendar date in such cases coincides with a Sunday, it is usual to provide that the actual observance shall take place on the first lawful day before or after.

In the case, for example, of the Scotch half-yearly term days, it is provided that if these fall on a Sunday the term is observed on the day following.

In like manner, if 1st January or 25th December falls on a Sunday, the Scotch Bank Holiday which is enacted for these days is observed on the Monday following.

The Court of Session in Scotland commences its Winter Session on the 15th of October or the first sederunt day thereafter. The sederunt days of that court are Tuesday, Wednesday, Thursday, Friday and Saturday. It follows that if 15th October falls either on a Sunday or a Monday the opening is postponed to the Tuesday following.

Conversely, in the English courts, if Call Day falls on a Saturday or a Sunday, it is observed on the Monday following.

In Class *B*, however, we have a large class of cases in which it has been found necessary or expedient to provide that the occurrence shall always take place on the same day of the week. In these cases the week day is the primary co-ordinate.

Easter, for example, by the decree of the Nicene Council,

must always be observed on a Sunday, and the anniversary of the Crucifixion must therefore necessarily always fall on a Friday.

There are many other cases of this rule. It is found convenient in most places that markets should be held weekly at suitable centres, and these are almost invariably observed always on the same day of the week. When, therefore, in certain cases once or twice a year a market of special importance is to be observed, it is natural that it should be attached also to a special week day.

To determine the recurrence of the date in such cases the usual expedient adopted is to fix the event in question for the first, second, third, fourth, or last Monday, Tuesday, or as the case may be of a particular month.

Thus, in Scotland the licensing magistrates meet for burghs on the second, and for counties on the third Tuesday of April, and for burghs on the third, and for counties on the last Tuesday of October. By the Act, 1661, ch. 38, Quarter Sessions were appointed to be held on the first Tuesdays of March, May and August, and the last Tuesday of October.

Sometimes, to endeavour to prevent a particular clashing which such dating has been found to involve, a further refinement is resorted to. Thus the annual meeting of the Educational Institute of Scotland takes place on the Saturday after the third Friday of September.

This discord between month day and week day is the most serious defect connected with the Calendar.

Every year on 1st January the almanac is completely changed. We are so accustomed to this defect that we do not realise its gravity. But what would we think if the same thing happened with the weights and measures?—if the pound which is this year 16 ounces became 15 ounces next year and 14 ounces the following year, and so on, returning to its original value only at distant and irregular intervals; or if the yard which this year is 36 inches became next year 35 and the next year 34, and so on; or what would we think if the letters of the alphabet or the nine numerals underwent a similar annual dislocation? Would we not be disposed to say that the whole fabric of society was

undermined? Yet hardly less serious is the dislocation caused by the disturbance of the order of the days of the week. Let us take one concrete instance of the effect of this.

Suppose, for example, that a market in Glasgow is fixed for the first Tuesday of July, and one in Edinburgh for the first Wednesday of the same month. In a year in which July begins with say a Monday or Tuesday, these two days would be in immediate juxtaposition with each other. For the service of these markets a great variety of special arrangements require to be made, not only by railway companies, but by many others as well. If the relation between these two days were a constant one, the arrangements made in one year would be a basis which could be founded on in subsequent years. Particular arrangements which proved inconvenient or ineffective would be improved or abandoned, and other expedients substituted, until gradually a more and more perfect working scheme would be arrived at; or if the juxtaposition were found to be altogether impracticable, one or other of the markets would be altered to a more convenient date. But under existing conditions such improvement is impossible. If the two days in question are in juxtaposition this year, because July begins on a Tuesday, next year when July begins on a Wednesday the first Wednesday is the first of the month, and the first Tuesday does not occur until the 7th of the month, being the Tuesday of the following week. All the arrangements made this year are, therefore, of no use or avail, and an entirely new set of arrangements must be devised, only, however, to be again shaken to pieces in the succeeding year when the two markets will again recur in juxtaposition. This, of course, is only one example of what is continually happening everywhere and always.

If the variations of the yearly Calendar were few in number, and always succeeded one another in a definite, rhythmic and easily intelligible order, it might be possible to adjust our time-tables and arrangements with some sort of corresponding harmony; but under our present Calendar the irregularities are too great to admit of this being done, a fact which will be very evident from a consideration of the accompanying table, show-

ing in successive columns the years between 1901 and 1952, which have identical Calendars.

An absence of progress is a feature of all the arrangements provided for the regulation of human action. If we compare a Statute or Act of Parliament of a hundred years ago with one passed last session, not only do we find no improvement in its conception and draughtsmanship, but the comparison is, if anything, unfavourable to the more recent production. The organisation of labour, or of the traffic of our streets, the arrangement of business in Parliament, in the Law Courts, or in the Stock Exchange, reveal no evident signs of steady and constant improvement. No doubt there are many changes, and more than enough of novelties and alterations, but of a general orderly continuous progress there is really no appearance.

Let us contrast this state of affairs with the remarkable and continuous progress which, for more than a century, has been taking place in scientific knowledge, and in the application of science to the arts. The constant improvement in the conditions of civilised life in modern times bears unceasing testimony to the reality of this progress. We visit an engineering museum, and we see there a model of Stephenson's first locomotive along with a succession of subsequent designs, down to the magnificent engines of to-day. The same thing occurs if we examine an exhibition of electrical apparatus, of ships, of motor cars, or indeed of any sort of scientific or mechanical contrivance designed for the service of mankind.

It is to the advance of scientific knowledge and its applications that the remarkable amelioration of the conditions of civilised life during the last century or so is due. And the very vastness and universality of this improvement usually blinds us to the fact that it has not extended itself to the regulation and organisation of human activity. Yet the ever growing unrest and discontentment, which are seething in all ranks of society, bear conclusive testimony to the fact that there is something sadly unsatisfying and far amiss in the social condition, even of the most civilised states.

Now what is the cause of this strange contrast? The answer is that progress is only possible where improvement is cumu-

The Years with Identical Calendars 1901-51.

1901													
	1902												
		1903											
			1904										
				1905									
					1906								
1907													
						1908							
							1909						
								1910					
				1911									
									1912				
	1913												
		1914											
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										1916			
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1918													
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											1920		
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		1925											
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1929													
	1930												
		1931											
			1932										
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	1941												
		1942											
							1943						
										1944			
					1945								
1946													
	1947												
											1948		
								1949					
				1950									
					1951								
												1952	

Fig. 11

lative. The modern locomotive, the modern "Cunarder," the modern motor car, or telephone exchange have not leaped fully equipped from the brain of the inventor. On the contrary, their improvement has been a gradual and continuous process. In the case of the locomotive, starting with Stephenson's "Rocket," its defects were noticed, improvements one by one were tried and tested, the good were retained, the defective were discarded, and in this way the engineer has arrived at the locomotive of to-day. And only because he could proceed thus was the improvement possible.

The remark is of universal application. In short, the course of scientific progress resembles the erection of a building. Just as St Paul's Cathedral rose surely and gradually as one row of stones were laid upon another, so has the course of mechanical improvement gone on its way.

But such gradual building is only possible upon a fixed and steady foundation. If an earthquake were annually to shake to the ground all the work of the preceding year, obviously neither St Paul's Cathedral nor any other similar edifice could ever have been reared. And in like manner a basis of fixed data is the essential pre-requisite of all social and administrative improvement. In short, we may say that all such progress is impossible, that all efforts towards its attainment are futile, until we establish as its basis a perpetual calendar.

II. When we consider the Calendar as an instrument for measuring intervals of time we find it also deficient in the following respects:

(1) The half years and quarters are unequal. It is true that as the year consists of 365 days absolute equality is impossible, but an equal division of 364 days leaving only *one* day over in common and *two* days in leap years would be perfectly practicable; would greatly facilitate the calculation of apportionable payments, and would ensure that each trimestre contained 13 complete weeks.

(2) The month lengths are unequal. In this case again absolute equality is impracticable, but there would be no difficulty in arranging that no month should differ by more than one day from the standard length of 30 days. The wages of sailors are

usually paid and calculated by the month which is treated as consisting of 30 days, so that one day's charge is held to be 1/30th of the monthly amount, a rule which sometimes favours the employer and sometimes the servant, but which works in practice. The closer, however, that the approximation can be made to the standard so much the better, and there is no doubt that, in accounting, considerable advantage would result if no month deviated by more than one day from the standard length.

(3) The third defect is the want of a convenient common measure for comparison of monthly and weekly apportionments. This is the proper function of the quarter which can easily be standardised so as to consist of 3 months, 13 weeks, or 91 days.

XVIII

HOW ITS DEFECTS MAY BE REMEDIED

We now approach the question of how the foregoing defects can be made good most simply and effectively and with the least possible disturbance of continuity. We shall deal first with the rearrangement of the days of the year, so as to provide us with equal half years and quarters. This is really the most elementary and fundamental problem. We shall then take up the immensely important problem of how to establish a stable and permanent correspondence between month day and week day.

I. Many proposals have been made for such a readjustment of the months as would provide four equal quarters and two equal half years, at the same time rearranging the month lengths in a rhythmical order of 31, 30, 30 or 30, 30, 31.

To all these changes two objections have been stated, *viz.*:

(1) That they err by excess in that—merely for the sake of a symmetrical appearance—they make an unnecessary amount of change in the long established syllabus.

(2) They all involve an alteration in the date of the vernal equinox, which is the most important date in the Gregorian Calendar, being that from which are reckoned the right ascensions of the stars, and on which also are based the tables constructed for the calculation of Easter. Indeed, as we have seen,

it was to fix this date that the Gregorian reform was introduced. It is important, therefore, to note that the inequality of the half years can be corrected much more simply.

All that is necessary is to subtract a day from August and add it to February—thus undoing the transfer from February to August alleged to have been perpetrated by Augustus Caesar.

It will be found that this simple change provides us with two equal half years and four equal quarters, subject always of course to the exclusion of the 365th and 366th days. It does this not only in the case of the Calendar year commencing on 1st January, but also if we take the ecclesiastical twelve-month beginning on 1st December, or the twelve-month from 1st March —the latter being for many purposes an extremely useful period.

It is further to be noted that if the day taken from August *be added to the February of the following year* the change effected in this way leaves the date of the vernal equinox and all its consequents—indeed all dates from 1st March to 30th August—absolutely unaffected.

It is indeed remarkable how much the Gregorian Calendar is simplified and improved by this one altogether harmless change:

(1) It provides a scheme of months, of which in common years all except February, and in leap years all without exception, are either of 30 or 31 days in length, and in no case does any month differ by more than one day from the standard length.

(2) Subject only to the sequestration of the 365th day it provides us with two equal half years and four equal quarters. Under the present Calendar one quarter contains 90 days, one 91 and two 92 days each. Under these conditions the employment of equal quarterly divisions is impracticable, but there is nothing impracticable in setting aside the *one* extra day and thus providing ourselves with the four equal quarters for the calculation of apportionable payments.

(3) Each quarter would then contain exactly three months and 13 complete weeks. It would thus furnish us with the much-needed common measure for the comparison of monthly and weekly apportionments.

Although the quarter or trimestre is not usually regarded as one of the elements of the Calendar it has a true natural position

A PERPETUAL GREGORIAN ALMANAC.

Commencing 29th February, 1920.

SPRING			SUMMER			AUTUMN			WINTER		
March	April	May	June	July	Aug.	Sept.	Oct.	Novr.	Decr.	Jan.	Feb.
1 S.	1 W.	1 F.	1 S.	1 Tu.	1 F.	1 S.	1 Tu.	1 F.	1 S.	1 W.	1 Sat.
2 M.	2 Th.	2 Sat.	2 M.	2 W.	2 Sat.	2 M.	2 W.	2 Sat.	2 M.	2 Th.	2 S.
3 Tu.	3 F.	3 S.	3 Tu.	3 Th.	3 S.	3 Tu.	3 Th.	3 S.	3 Tu.	3 F.	3 M.
4 W.	4 Sat.	4 M.	4 W.	4 F.	4 M.	4 W.	4 F.	4 M.	4 W.	4 Sat.	4 Tu.
5 Th.	5 S.	5 Tu.	5 Th.	5 Sat.	5 Tu.	5 Th.	5 Sat.	5 Tu.	5 Th.	5 S.	5 W.
6 F.	6 M.	6 W.	6 F.	6 S.	6 W.	6 F.	6 S.	6 W.	6 F.	6 M.	6 Th.
7 Sat.	7 Tu.	7 Th.	7 Sat.	7 M.	7 Th.	7 Sat.	7 M.	7 Th.	7 Sat.	7 Tu.	7 F.
8 S.	8 W.	8 F.	8 S.	8 Tu.	8 F.	8 S.	8 Tu.	8 F.	8 S.	8 W.	8 Sat.
9 M.	9 Th.	9 Sat.	9 M.	9 W.	9 Sat.	9 M.	9 W.	9 Sat.	9 M.	9 Th.	9 S.
10 Tu.	10 F.	10 S.	10 Tu.	10 Th.	10 S.	10 Tu.	10 Th.	10 S.	10 Tu.	10 F.	10 M.
11 W.	11 Sat.	11 M.	11 W.	11 F.	11 M.	11 W.	11 F.	11 M.	11 W.	11 Sat.	11 Tu.
12 Th.	12 S.	12 Tu.	12 Th.	12 Sat.	12 Tu.	12 Th.	12 Sat.	12 Tu.	12 Th.	12 S.	12 W.
13 F.	13 M.	13 W.	13 F.	13 S.	13 W.	13 F.	13 S.	13 W.	13 F.	13 M.	13 Th.
14 Sat.	14 Tu.	14 Th.	14 Sat.	14 M.	14 Th.	14 Sat.	14 M.	14 Th.	14 Sat.	14 Tu.	14 F.
15 S.	15 W.	15 F.	15 S.	15 Tu.	15 F.	15 S.	15 Tu.	15 F.	15 S.	15 W.	15 Sat.
16 M.	16 Th.	16 Sat.	16 M.	16 W.	16 Sat.	16 M.	16 W.	16 Sat.	16 M.	16 Th.	16 S.
17 Tu.	17 F.	17 S.	17 Tu.	17 Th.	17 S.	17 Tu.	17 Th.	17 S.	17 Tu.	17 F.	17 M.
18 W.	18 Sat.	18 M.	18 W.	18 F.	18 M.	18 W.	18 F.	18 M.	18 W.	18 Sat.	18 Tu.
19 Th.	19 S.	19 Tu.	19 Th.	19 Sat.	19 Tu.	19 Th.	19 Sat.	19 Tu.	19 Th.	19 S.	19 W.
20 F.	20 M.	20 W.	20 F.	20 S.	20 W.	20 F.	20 S.	20 W.	20 F.	20 M.	20 Th.
21 Sat.	21 Tu.	21 Th.	21 Sat.	21 M.	21 Th.	21 Sat.	21 M.	21 Th.	21 Sat.	21 Tu.	21 F.
22 S.	22 W.	22 F.	22 S.	22 Tu.	22 F.	22 S.	22 Tu.	22 F.	22 S.	22 W.	22 Sat.
23 M.	23 Th.	23 Sat.	23 M.	23 W.	23 Sat.	23 M.	23 W.	23 Sat.	23 M.	23 Th.	23 S.
24 Tu.	24 F.	24 S.	24 Tu.	24 Th.	24 S.	24 Tu.	24 Th.	24 S.	24 Tu.	24 F.	24 M.
25 W.	25 Sat.	25 M.	25 W.	25 F.	25 M.	25 W.	25 F.	25 M.	25 W.	25 Sat.	25 Tu.
26 Th.	26 S.	26 Tu.	26 Th.	26 Sat.	26 Tu.	26 Th.	26 Sat.	26 Tu.	26 Th.	26 S.	26 W.
27 F.	27 M.	27 W.	27 F.	27 S.	27 W.	27 F.	27 S.	27 W.	27 F.	27 M.	27 Th.
28 Sat.	28 Tu.	28 Th.	28 Sat.	28 M.	28 Th.	28 Sat.	28 M.	28 Th.	28 Sat.	28 Tu.	28 F.
29 S.	29 W.	29 F.	29 S.	29 Tu.	29 F.	29 S.	29 Tu.	29 F.	29 S.	29 W.	29 Sat.
30 M.	30 Th.	30 Sat.	30 M.	30 W.	30 Sat.	30 M.	30 W.	30 Sat.	30 M.	30 Th.	30 Leap Day
31 Tu.		31 Year Day		31 Th.			31 Th.		31 Tu.	31 F.	

Fig. 12

A. P., 18/6/17.

in the Calendar—a fact to which attention was directed by Pliny[1]. His point is that the equinoxes and solstices naturally divide the year into four parts. The conventional quarters of the Calendar do not of course exactly correspond to the astronomical intervals; but being adjusted to an equal length of 91 days they furnish the needed common measure between month and week. Independently of these physical facts the quarter or trimestre has been proved by experience to be in many cases the most convenient interval for settling periodical accounts, payments and engagements. Its use for these purposes—already extensive—would be facilitated were the equality of the four working quarters established.

Keeping these considerations in view we must next point out that the day to be excluded from computation in order to furnish the four equal quarters is evidently the 31st May. If that day be sequestrated we at once arrive at the four equal quarters, and it is important to note that this result is attained whether we commence with the ecclesiastical year on 1st December or with the 1st March. Moreover, if we commence to reckon our year either from 1st December or from 1st March, both the 30th February, which would be the odd leap day, and the 31st May, which we are suggesting for the annual sequestration, would fall *at the end of a quarter*. In either of these periods of computation, therefore, the four quarters would be compact and continuous and would never suffer any interruption as a result of these days being so excluded from enumeration.

It ought to be pointed out here that whilst it would be inadvisable and undesirable to make any alteration in the commencement of the Calendar year *for purposes of dating* it is quite unnecessary, and is not even desirable, to adhere to that starting point in computing intervals of time. In point of fact we seldom do so at present. In the engagements of servants or the letting of houses or lands, in fixing the terms and sessions of law courts, schools and universities, in settling the financial year of public authorities, commercial companies and private business firms we seldom adhere to the Calendar year, and no inconvenience results. Indeed it is for many reasons undesirable

[1] *Hist. Nat.* Lib. XVIII, cap. 25.

to do so. Seasonal conditions render it frequently inexpedient, and in any case the proper course is to distribute the dates of such intervals to several positions throughout the year and not permit them all to accumulate at one date.

II. We now address ourselves to the problem of the establishment of a perpetual correspondence between month day and week day.

We at once remark that the only practical solution is to exclude one day annually and the odd day in leap year from enumeration *as days of the week.*

The immediate effect of this simple expedient would be to bring a Perpetual Calendar into operation without any disturbance or inconvenience.

Consideration should be given to the selection of a suitable date at which to introduce the reform, but if that be attended to no confusion or disturbance need be anticipated. Many proposals with this end in view have been published during recent years. In the majority of cases these proposals have suggested that the day to be set apart annually and the 366th day in leap year should be excluded not only from the weekly but from the monthly enumeration. This, however, is both unnecessary and undesirable. It is important to preserve unbroken for dating purposes the established enumeration of every day of the year by reference to one or other of the twelve Calendar months. This can quite easily be secured by the simple precaution of selecting as the day to be excluded, the *last* day of one or other of the months. To all intents and purposes the odd day in leap year is the last day of February, although theoretically it may be the 24th, and the simple solution, therefore, is to exclude the last day of February in every leap year and the last day of some other 31-day month in common years from the weekly series.

The only objection which has been stated to this reform is the religious objection that it interferes with the unbroken continuity of the seven-day week, and, therefore, implies an infringement of the Divine Ordinance expressed in the Fourth Commandment.

It is thought that this objection is unfounded. The observance

of additional Sabbaths was recognised and strictly enjoined amongst the Jews, and indeed certain Sabbaths such as Pentecost and the Feast of Trumpets were officially duplicated—a rule still observed. The injunction "Six days shalt thou labour" is as much a part of the Fourth Commandment as the injunction to "Remember the Sabbath Day," yet no one supposes that he is thereby prevented from observing a holiday or a half holiday, not only occasionally, but every week.

The spirit and purpose of the Fourth Commandment is to ensure the devotion of one-seventh of our time to rest and worship. This object would not only be still secured but would be much more effectively secured if the week were placed in a perpetual relation to the other elements of the Calendar. Its significance and importance would be increased, its preservation would be assured and the whole scheme of the Christian year would be rendered practicable to an extent hitherto unrealised.

The Christian Church has not hesitated to transfer the observance of the weekly rest day from the seventh to the first day of the week—a fact which proves conclusively that it is the spirit and not the letter of the commandment to which we owe allegiance. And it may be incidentally noticed—as was well remarked recently by Père Bertrand—that theoretically at any rate such a shift could not have taken place without the intervention either of two Sabbaths in immediate succession or of one week of eight days. If such an interruption in the unbroken succession of seven-day weeks was permissible once it is vain to suggest that its regular observance annually would involve any disregard of the Divine Command. On the whole matter it may safely be said that the objection is based on an ill-informed literalism, and displays a real ignorance of the history of the Sabbath.

It has been suggested that to avoid this objection it might be arranged to reduce the normal length of the year under the Gregorian Calendar to 364 days, allowing the overplus to accumulate till it amounted to a week and intercalating an additional week every seventh and an additional fortnight every twenty-eighth year. If this were done there is no doubt but that

a Perpetual Calendar would be established without any interruption in the succession of week days[1].

The change would involve a serious interruption in the continuity of the Gregorian Calendar. It would be a departure from the principle on which the Julian Calendar was based, *viz.* the reduction of intercalations to a minimum. A large and disturbing oscillation would take place in the dates of the Ephemerides, and the practical use of the Calendar for scientific purposes would be impaired. Its value also for statistical purposes would be adversely affected. It seems incredible that science would submit to such inconveniences and disturbance for no other reason than to pay deference to a fanciful prejudice begotten of unhistorical conceptions of the origin and use of the seven-day week.

We now return to the question, "What day is most suitable to be excluded from the weekly series?"

It is obviously expedient that each of the four quarters should comprise 13 complete weeks, beginning with a Sunday and ending with a Saturday. Now that result is at once attained if we select for exclusion from the weekly series the very same days, namely 30th February in leap years, and 31st May annually, which we have already found it desirable to set apart in arranging the four equal quarters of the year.

If these days are selected then the 29th of February and the 30th of May should be Saturdays, and the 1st of March and the 1st of June should be Sundays. Now this result can be at once secured by commencing the ecclesiastical year with a Sunday on 1st December. In that case each of the four quarters starting from that date will commence with a Sunday and end with a Saturday and will comprise 13 complete weeks.

In the proposals which have been recently published for rearranging the month lengths in symmetrical quarters either of 30, 30, 31 days or 31, 30, 30 days, the reason for suggesting the latter alternative has been to secure that each month should comprise the same number of working days, and at the same time each quarter should commence with a Sunday. The mis-

[1] Such a year of 364 days with an intercalary week has actually been employed in Iceland. See also Mr F. A. Black, *op. cit.* p. 150.

take has been in supposing that the year from this point of view must commence with a Sunday on 1st January. That, as we have seen, is unnecessary. The proper course is to commence the ecclesiastical year with a Sunday on 1st December. In so far as the Calendar is employed as an instrument of dating, it is altogether immaterial with what week day 1st January coincides. Under the proposed Perpetual Calendar 1st January would be a Wednesday, and the months, if arranged in a series of 30, 30, 31, commencing with January, would each contain 26 working days. It is interesting to note that in that Calendar 1st March would also be a Sunday. Under the line of Epacts now in force, and which holds good until 2199, Easter Sunday would fall on one or other of the five Sundays which in the proposed Perpetual Calendar would be the 22nd March, 29th March, 5th April, 12th April and 19th April. Now as Easter never falls on 22nd March whilst the present line of Epacts is in force, it follows that until 2199 Easter would always fall on one or other of the four other Sundays, and the amplitude of the oscillation would be reduced from 35 to 22 days. Moreover, the existing Prayer Book table for the determination of Easter, which we printed in Section XV, would still be available without correction for the ascertainment of the Easter date, although it would be unnecessary to refer to the supplementary table for the Dominical Letter, which would always be *D*. Under this simplified arrangement Easter Sunday would still always fall during the period of evening moonlight, a circumstance to which much importance was at one time attached by the ecclesiastical authorities.

Were Easter to be absolutely fixed to one particular Sunday, that last condition could no longer be fulfilled, but in the event of such fixture being determined, it seems obvious that the proper date to select would be Sunday, 12th April. This date approximates very nearly to the most probable date of the Resurrection, and it has this immense advantage that an interval therefrom of 50 days takes us exactly to 31st May as the proper date for Pentecost. Thus the festival of Pentecost, the only one which has passed on unaltered from the earliest Jewish times, and which is now recognised throughout the Christian Church as the anniversary of its foundation, would exactly, and most

appropriately, coincide with the day already, for other reasons, specially set apart and excluded from the ordinary series of week days.

The custom of the Jews from the earliest times and until the present day has been to set aside two successive Sabbaths for the celebration of Pentecost. Historically, therefore, there would be strong justification for the observance of a special Whit-Sunday on 31st May, followed by an ordinary Sunday on 1st June. The 31st May is the central day of the ecclesiastical year commencing 1st December.

A number of proposals have been published in recent years for the division of the year into 13 months of 28 days or four weeks each. Such proposals seem to proceed, to a certain extent, upon a misunderstanding.

If a perpetual Gregorian Calendar were adopted one result would be that each of the 52 weeks would occupy—as the months do at present—a definite position in the year. Each week, therefore, would become identified by a special number and name, would in fact acquire the individuality which, in an earlier section of this essay, we had occasion to observe that the week cannot at present attain. The importance and the utility of the seven-day week would be enlarged. There would be nothing to hinder the grouping of weeks thus identified in sets of four, or in successive stages of four, four and five, as has also been suggested.

No legislative enactments would be necessary for this to be done, and there would be nothing to hinder those who found it convenient to make use of such grouping of weeks. It would, however, be altogether unnecessary to accompany these arrangements by an attempt forcibly to abolish the use *for dating purposes* of the familiar and well-known twelve-months. It is unlikely that a prohibition of such use could be enforced. The attempt to do so would be disastrous and productive of endless confusion, and would certainly not forward the object which the advocates of these four-week groupings have in view.

It is widely believed that sooner or later a fixed correspondence will be established between month day and week day. Otherwise the observance of Sunday as a weekly blank day in

business will be imperilled. Now if that correspondence is established there will inevitably follow an increasingly urgent demand for four quarters each containing 13 complete weeks. We have already pointed out that such a change would be in several other respects highly advantageous—for example, in connection with the calculation of apportionable payments.

That simple reform should, therefore, be taken in hand without delay. It can, as we have seen, be most easily accomplished by the transfer of one day from August to February, and if desired the transfer can be so effected as to leave the date of the vernal equinox unaffected.

This change, though so small and simple, is in itself important, and it is really the only change of the Calendar which directly affects its use in scientific work. Men of science, therefore, so far as this change is concerned, should not merely look on but should take active measures for its adoption. It would remove the one serious and outstanding defect in the Gregorian Calendar properly so called.

Admitting that it is desirable that any reform should be comprehensive and complete we still maintain that simplicity and efficiency would be best secured by the adoption of this one change as a first preliminary step. Thereafter, the whole position could be reviewed with a clearer understanding of what was still required and that, we are satisfied, would be found not to involve any further interference with the Calendar as used by science.

It is indeed possible that by the adoption of tables of week day periods[1] all further legislative interference might be rendered unnecessary.

[1] For a description of these see the author's essay, *A Plea for an Orderly Almanac.*

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